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The Blast Furnace and Steel Plant

VOL. VII. PITTSBURGH, PA., MAY, 1919. No. 5

Metallurgical Considerations of Duplexing

The First of a Series of Articles on the Duplex Process. The Acid Bessemer Stage—Essential Features in the Operation of Large and Small Converters.

By RICHARD S. M'CAFFERY,
Prof. of Metallurgy, University of Wisconsin.

PART I.

This article written by R. S. McCaffery, Professor of Metallurgy at the University of Wisconsin, is the first of a series of three articles on duplexing. The first installment of this series deals with the Bessemer stage; the second will deal with the open hearth stage, and the third will consider the relation between these two processes, the quality of the product and possible modification or departures from standard American practice. Throughout the entire series the subject will be considered solely from the viewpoint of metallurgical and physical chemistry. The increasing interest in the duplex process combined with the fact that many new duplex plants have been built employing larger converters than were attempted in the past, makes this series of particular interest and value.

In this paper the particular duplex process discussed will be that commonly so called in the United States in which blast furnace iron is first treated in an acid Bessemer converter and finished in a basic open hearth furnace. The purification of pig iron presented a problem that was not solved technically by either the Bessemer or open hearth process, the main difficulty being the elimination of silicon and phosphorus. Silicon is removed by oxidation to silica, SiO_2, which results in the formation of an acid slag. Phosphorus is also removed by oxidation to phosphoric acid, P_2O_5, but strongly basic substances must be present to combine with the oxidized phosphorus and a very basic slag must be formed. The corrosion of an acid refractory by a basic slag and of a basic refractory by an acid slag compelled the conduct of the processes in furnaces which had the quantities of scrap on their charge, diluting in this The elimination of silicon, resulting in an acid slag, could best be carried on in an acid lined furnace and as phosphorus elimination requires basic slag conditions, the removal of the two elements could not be effected in the same furnace. Economically this resulted in the acid process being employed when the pig was low in phosphorus and no removal of the phosphorus was attempted, while basic processes used irons of low silicon content to keep to a minimum the silica that would require neutralization. For example Bessemer pig is that low phosphorus pig which when made into steel by the acid Bessemer process gives a steel that is satisfactory for most purposes without any phosphorus removal and basic pig is low silicon, low sulphur, high phosphorus pig that is manufactured into steel in basic open hearth furnaces and the high phosphorus removed.

At steel works there is always a large amount of scrap steel, billet croppings, etc., including the pipe ends of ingots which must be remelted, and steel scrap, the waste of industry, which can be purchased and recast into ingots. For these reasons open hearth steel plants employ large quantities of scrap on their charge d,iluting in this way the silicon and carbon content of the pig which is used in addition to the scrap.

This works satisfactorily while scrap is available and the low silicon, low carbon charge could be successfully treated, when high in phosphorus, in basic open hearths; so that the standard American practice in a general way was to utilize low phosphorus pig in the manufacture of acid Bessemer steel and high phosphorus pig was treated in basic open hearths along with the scrap available. With increasing phosphorus content of ores and the difficulties in procuring scrap, a combination process was resorted to and the American duplex process in which the acid Bessemer converter is used for desiliconizing and decarbonizing, and the basic open hearth for dephosphorizing is the outcome. The latest development of the duplex process, instead of carrying out a complex series of reactions in one furnace, which while it may function well for certain of the reactions cannot do so for all, employs the acid converter for eliminating silicon and carbon, both of which functions it is best adapted for, and finishes the blown metal in basic open hearth furnaces. The latter are then furnished with an iron containing no silicon nor carbon and they are called on only to eliminate phosphorus for which they are well suited. The process is divided up into stages, and each step employed on that part of the work which it does best. In addition, each stage works on a raw material of the best character for its proper functioning.

Mr. T. W. Robinson, vice president, Illinois Steel Company, has stated in *Iron Age* (1898, p. 1036) that "steel scrap or its equivalent is an economic necessity for the straight open hearth process * * * but the underlying cause of the growth of the duplex process is its independence of a steel scrap supply." The object of duplexing then is to furnish the basic open hearths with a supply of molten scrap.

In a duplex steel plant several important features should be present in the ideal installation, according to Quincy Bent of the Bethlehem Steel Company. *Iron Age*, 1898, p. 1036). They are:

1. An ample supply of molten pig iron sufficiently high in heat producing elements to assure long blows with or without the addition of a small amount of scrap.
2. A fair reservoir of hot metal providing a good mixture of iron as it is produced by the various blast furnaces.
3. A close proximity of mixers, converters and open hearth furnaces with ample means for rapid and regular transportation between the three divisions.
4. Converters of as large a capacity as practical, 25 or 30 tons, three of which can be blown simultaneously.
5. Crane and ladle capacity to collect these three heats and transfer them as a unit to the open hearth furnace.
6. Proper means of preventing the Bessemer slag from entering the open hearth furnace and facilities for the disposal of this slag.
7. Large tilting open hearth furnaces of 200 to 250 tons capacity.
8. Provision for recarburizing heats in the steel ladle.
9. Ample pit room and teeming facilities to handle the open hearth output.

The Acid Bessemer Stage.

The blast furnace iron for the duplex process is taken from the blast furnaces in ladle cars, transported to the steel plant and poured into the mixer serving the converters. The specifications for the iron used in the duplex process are broader than for either Bessemer or open hearth irons. Silicon is the most important element since it furnishes the larger part of the heat in the Bessemer blow and it must be present in sufficient amount to give this heat to the charge. Beyond this amount its presence lengthens the time of the blow and increases the power cost. On the other hand a blast furnace cannot desulphurize its iron product if this iron is too low in silicon; while increased silicon content of the iron means greater coke consumption in the blast furnace. Within recent years Bessemer converters have grown in size and their heat losses due to radiation, conduction, etc., have decreased, this in turn reducing the silicon necessary for fuel purposes in the converter so that generally speaking the silicon content of the iron for duplexing is about what it is cheapest to produce in the the blast furnace. This is around 1 per cent silicon, although most duplexing plants run somewhat higher. With sulphur the case is somewhat the same economically. It can be gotten out of the metal in the open hearths but the more sulphur that reaches the open hearths, the greater the expense of its removal there. This means duplexing iron should contain less than .06 sulphur and preferably be under .05 sulphur. The manganese may vary considerably. It is probably best about 1.25 per cent. This amount does not cause spitting and it is sufficient to keep the oxidation of the iron at a minimum. Phosphorus may be present in any amount, the limitation being the extra expense of removing large quantities. Of course very high phosphorus would suggest the possibility of the application of the basic Bessemer process.

The mixer in a modern plant should be large, the limit in size being what will give iron of the proper temperature for the converters without external heating. The larger size will tend to better equalize the composition of the blast furnace casts, will permit greater liquation of the sulphur content and will afford large storage capacity. The kish and slag from the mixer should not be permitted to reach the converters as they are high in sulphur, manganese and carbon and will contaminate the iron, increasing both the time of blowing and the cutting effect of the slag in the converter vessel. Modern duplexing converters in some respects operate differently than the smaller vessels previously used in straight Bessemer plants. The heat radiation is less, the heat capacity of the vessel itself is greater, and with the high blast pressure it is usual to employ, the cycle of the chemical reactions is somewhat changed. The converters of about 25 tons capacity when filled with molten iron 20 inches above the tuyeres, are charged with mixer metal by means of a transfer ladle, the vessel is upturned and the charge blown. If the temperature of the mixer metal is not too high, say about 1,300 or 1,350 degrees C., the normal Bessemer cycle, not considering subsidiary reactions, is as follows: The oxygen of the blast passing through the molten metal oxidizes the iron to magnetic oxide of iron, Fe_3O_4, and to a lesser extent the manganese to MnO. These two oxides are the active oxygen carriers in the molten bath and the silicon of the iron becomes silica, which reacts with the bases present to form a silicate slag thus:

$$Fe_3O_4 + 2\ Si = 3Fe + 2\ SiO_2.$$
$$2MnO + SiO_2 = Mn_2\ SiO_4.$$
$$Fe_3O_4 + SiO_2 = Fe_2\ SiO_4 + Fe.$$

These reactions lead to a very rapid increase in temperature of the molten bath in the vessel and at this high temperature, the affinity of carbon for oxygen increases so that the carbon begins to burn. The two following reactions now begin to prevail.

$$Fe_3O_4 + 2C = 3Fe + 2CO_2$$

while the temperature is lower and

$$Fe_3O_4 + 4C = 3Fe + 4CO$$

as the temperature gets higher. During the first stage of the blow, when the oxidation of the silicon was predominating, there was little flame; the gases coming from the converter mouth being red hot nitrogen with showers of sparks of projected metal. When the carbon stage of the blow commences, a slight but decided flame appears, only slightly luminous at first but growing in density and of yellowish red color. As the amount of carbon monoxide formed in the vessel increases, this carbon monoxide burns at the mouth of the converter with the oxygen of the air to carbon dioxide, the flame increases in size and brilliancy and the boil of the charge in the vessel takes place. Silicon and manganese are completely slagged before this stage is reached and only carbon is burning. The action in the vessel diminishes as the fuel is burned up, the sparks decrease, the flame becomes less luminous and shorter and suddenly drops when the carbon content of the charge has reached about 1 per cent carbon. The converter is now turned down and the contents poured into a ladle for transfer to the open hearth furnace. While generally the chemical reactions of the blow are as stated above, they are not quite so simple due to the fact that the various impurities in the charge are not in the elemental condition but are in combination with the iron and manganese, the silicon probably forming iron silicide $FeSi$ and manganese silicide Mn_7Si_2, and the carbon forming iron carbide, Fe_3C, and manganese carbide. MnC_2. The other impurities, sulphur and phosphorus, form sulphides and phosphides. In the acid Bessemer process, sulphur and phosphorus are not removed and they will not be considered here as they have no effect on the heat balance of the operation. The carbon silicon and manganese are all oxidized in the acid Bessemer and the effect of them and their compounds must be reviewed to get a clear idea of what happens under different conditions during the blow. As stated above, silicides of iron and of manganese are both present in mixer metal but the relative amount of the two is impossible to determine, although probably much more iron silicide is present than manganese silicide. The relative amounts of the carbides of iron and of manganese are not known nor is it possible to say how much of the iron is present as silicide or as carbide and the same is true of the manganese silicide and carbide. The importance of these different compounds is due to the fact they have different heats of combustion and their presence to a greater or lesser extent affects materially the temperature of the molten bath during the blow and this in turn, the order of the reactions which take place.

Certain phenomena occurring during the acid Bessemer blow have been considered in some detail by the writer BLAST FURNACE AND STEEL PLANT, March, issue; in addition to what was there stated, further details may make clear certain of the obscure points. After a large converter is charged with mixer metal that is very hot and of high silicon content, the normal blow previously described may not take place at all, but the temperature may rise very rapidly in the vessel in the beginning and the carbon oxidize and be removed before the silicon is eliminated. On the drop of the carbon flame, if the vessel is turned down, the residual silicon will be high and in a case like this the blow should have continued until heavy brown fumes come forth indicating the silicon is all slagged and that the converter can be turned down. In small converters an abnormal blow with silicon eliminated after the carbon was unusual but in large vessels for reasons already stated, temperature rise may be very rapid and such blows are not unknown. Some operators who are experienced only in the handling of the older, smaller converters may be interested to know the large converters can be started up early Monday morning after being down over Sunday without preliminary heating, requiring sometimes only a small addition of ferro-silicon to the metal.

Small furnaces generally are more difficult to operate than larger ones, which is true also of Bessemer converters, but certain procedure necessary in the smaller vessels is absolutely detrimental in the larger converters. In a small vessel there is much less margin of safety in the heat balance which would make it desirable to have an excess of fuel present and if the temperature became too high to reduce it by the addition of cold metal scrap. This was one of the common methods of temperature control in practice; in addition steam is introduced with the blast so that the heat absorption during the steam decomposition will cool the molten metal. Of course the temperature must be under control when a large vessel is used, but there is far less excuse for large scrap additions and for much steaming with them than with the smaller converters. With the large converters there has been a tendency to raise the blast pressure too high, the result being that the air furnished by the blast engines was used in the vessel to burn the carbon to carbon-dioxide, instead of burning it to carbon-monoxide with half the air, and then burning this carbon-monoxide at the converter mouth with the oxygen from the atmosphere at no cost. The power cost is not only raised by doing this and capacity cut down (See March issue) but the carbon burning to dioxide in the vessel with the formation of 97,200 calories against the formation of 29,160 calories when burned to monoxide results at times in abnormally high temperatures in large converters, making necessary excessive scrapping or excessive steaming, or both. In a process, one of the prime objects of which is to produce scrap, it seems foolish to have to add scrap and it also seems foolish to use more power to produce more heat to use more steam to absorb this heat.

It is not the intention to minimize the necessity of temperature regulation in larger converters for its great importance is pointed out in the article referred to above. In a large duplexing plant there would seem to be better and cheaper methods of temperature control than the above. Greater uniformity of analysis of mixer metal will aid in getting correct temperatures and large mixers are better for this purpose than small ones. In addition there is opportunity for temperature control by regulation of the carbon burning to monoxide or dioxide. Temperature control between small limits may be obtained quickly with the use of steam but within wider limits more scientific and decidedly cheaper methods are by analysis control and utilization of carbon heating. The writer believes that in large converters more carbon is burned to dioxide than is generally supposed and if this be correct the control of temperature by monoxide of dioxide burning is well within the possibility.

The usual open hearth charge in duplexing is made up of a number of Bessemer heats, soft blown, which are transferred to the open hearth as finished with the addition, toward the end, of a partially blown charge called the "kicker" for the purpose of adding some carbon to the open hearth bath to facilitate the phosphorus removal. This "kicker" charge is blown exactly as are the soft blown heats, except it is turned down before the drop of the flame and when its carbon content is from 1 per cent to 6 per cent. In transferring blown metal to the open hearths, care should be taken that no Bessemer slag is introduced into the basic furnaces. The slag should be poured off the ladles or if necessary, the ladles teemed to prevent the slag entering the open hearths when the metal is poured in.

The converter lining of ganister rock can usually be constructed to afford a long life but the replacable bottoms which contain the tuyeres are rapidly corroded and unless the proper material and workmanship is used, may be an item of considerable expense. Bottoms are made by inserting separate clay tuyere pieces through a tuyere plate, placing between these tuyeres silica brick blocks and ramming the spaces with a mixture of ground ganister and old tuyeres with just sufficient refractory clay to act as a binder. Air operated tampers give more uniformly rammed and better bottoms than hand tamped ones. The bottoms are dried and baked in ovens before they are used and are placed on the converter body while they are hot. The bottoms should be absolutely free from moisture and the proper baking of bottoms is as important as the making of them. Great care should be employed, too, in the selection of bottom material and the only way to secure uniformly satisfactory results is to make laboratory tests of all refractories.

Modern Reduction Gear for Turbine Service

Gears and Pinions of Stub-Tooth Double Helical Type—Bearings Split Horizontally to Permit Replacement Without Removing Couplings—Forced Feed Oil System.

Terry reduction gears manufactured by the Terry Steam Turbine Company of Hartford, Conn., are again on the market, not having been obtainable during the last year, due to the concentration of this company almost entirely on turbines for the destroyers. Although made primarily for sale with Terry turbines, the gears alone are available whenever a high grade reduction gear is desired.

In the design of Terry gears the same qualities which made the Terry turbine so popular, namely, simplicity, reliability and interchangeability, have been incorporated. There are a number of features of design which are particularly interesting.

The Terry gears and pinion are of the stub-tooth, double helical type, generated to true form on a Fellows gear shaper. The accuracy of this method of tooth generation is such that no grinding or scraping process is necessary to insure perfect contact of tooth surfaces. The gears and pinions are interchangeable, an advantage not often found where the final finish of the teeth is by grinding or scraping.

A well ribbed, double walled, box-like structure, extending the full depth of the case, forms a rigid support for each pair of bearings. The space between the walls acts as a water jacket for cooling the oil. The ribs between the walls act both as stiffening members and water baffles. The central part of the case, directly under the gears, forms an oil reservoir which contains sufficient oil to supply not only the gears, but also the turbine.

The case being of the double walled, rigid, box-like structure, accurate maintained alignment of the gears is insured. The casing is bored with the aid of fixtures, the dimensions and alignment of the boring being checked by accurate gauges. This results in a tight and rigid fit of the bearings.

The bearings are of ample size, insuring safe pressures and rubbing speeds. They are split horizontally to permit their replacement without removing the couplings. The bearing shell is of cast iron and, as can be seen by the accompanying cut, is unusually heavy. This is to prevent warping or "pinching-in" from heating, which so often occurs in thinner shells of bronze or similar metal. The lining used is of

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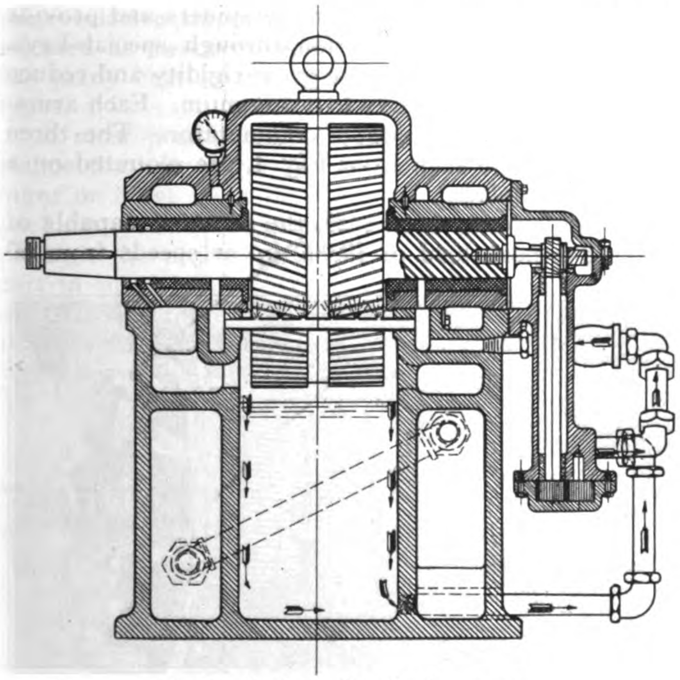
highest grade tin-base babbitt on both gear and pinion. The bearings are accurately machined to close limits and require very little scraping. Their interchangeability makes it possible in case of excessive wear, to easily and quickly replace them and restore the original alignment.

The oiling system employed is particularly interesting. It is a forced feed system, the ring oiling system having been found unsatisfactory for turbine reduction gear bearings. By reference to the sectional view, it will be noted that the oil pump is located well below the oil level in the reservoir, to avoid suction lift, thereby preventing ruin of the gears, due to possible failure of the pump to function. The oil is pumped from the reservoir through short, direct, brass piping to a self-cleaning strainer, thence through distributing passages to large, annular oil pockets around each bearing shell, and through the spray pipe from which the oil is sprayed, for lubrication of the gear teeth. The oil pressure gauge is located in one of the above-mentioned annular oil pockets at the most distant point from the oil pump.

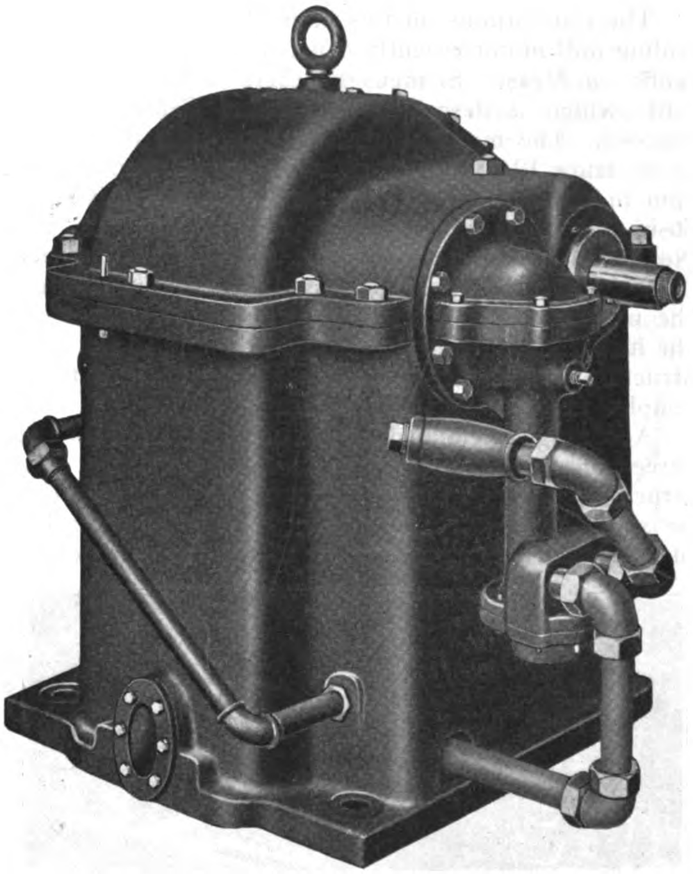


Sectional view of reduction gear.

The pump and its bevel gear drive make a complete unit without stuffing boxes, or exposed running parts. The unit is so constructed as to be easily accessible. The pump gears may be removed for inspection without disturbing the driving mechanism or oil piping. The bevel gears may also be inspected by removing a small cover. The effectiveness of this lubricating system has been proved by test for, without any water cooling, the temperature of the oil after long runs is less than that found in most gears when running with water cooling.

In spite of the cool operation of the gears, a water cooling system forms part of the standard equipment. This system is of particular interest, being in contrast to the usual method of water cooling coils. The water cooling jacket is hydraulically tested and when it is once found to be water tight it is certain that it will always remain so. Because the cooling jackets are in the bearing ends of the case, heated oil draining from the bearings and gears comes immediately into contact with the cooling surfaces before it has the opportunity to heat the oil in the reservoir.

The gears may be furnished for either direction of rotation, the only change being location of the oil spray piping above or below the contact point.



Exterior view of Terry gear with gear-driven oil pump from slow speed shaft.

In addition to the gear the Terry Steam Turbine Company manufactures a non-condensing turbine, the essential feature of which is that the multiple velocity effect necessary for highest economy in a single stage non-condensing turbine is obtained in a single row of totally enclosed radial buckets instead of a number of rows of exposed buckets having side clearances. The steam enters the nozzle in which it is expanded from approximately boiler pressure to the exhaust pressure. Issuing from the nozzle at high velocity, it strikes the side of the wheel bucket in which its direction is reversed 180 degrees. As the initial impact absorbs only a part of the total energy,, the jet of steam passes into the reversing chamber, which returns it to the wheel bucket. This action is repeated several times until all the available energy is obtained. The power-producing action of the steam in the wheel takes place entirely on the curved surface at the back of the bucket, the only function of the blades being to split the steam jet.

English Reversing Rolling Mill Motor

A 19,000 hp Reversing Motor for 36-Inch Roughing and Finishing Mill—Advantages Claimed for Three Armature Design—More Rapid Acceleration Obtainable—Total Weight of Motor 300 Tons.

The illustrations on this page show an interesting rolling-mill motor recently constructed at the Stafford works of Messrs. Siemens Brothers Dynamo Works, Ltd., which is described in London *Engineering* as follows: The motor, which on peak load is capable of exerting 19,000 hp at speeds from 60 rpm to 140 rpm in either direction, has been built for driving a 36-in. roughing and finishing mill situated on the Northeast coast. The motor is supplied with power from a motor-generator set fitted with a flywheel, on the well-known Ilgner system. The chief interest of the installation lies in its large power and in the construction of the motor, which is split up into three coupled units, as will be seen from Fig. 1.

Advantage is claimed by the manufacturers for the three-armature design over a double-armature construction, since, as the diameter of the armatures can be smaller the inertia is reduced, and the operation of the mill is improved owing to the more rapid acceleration obtained; also the distance between the centers is less and the weight on the bearings smaller than would be the case in a two-armature machine of similar power. It is also pointed out that the weight of individual parts is less with the three-armature construction, facilitating handling, and that the design assists towards standardization of parts, since by employing one, two or three of the units, motors of 6,500 hp., 13,000 hp, or 19,000 hp can be constructed. This might considerably reduce the cost of spares carried in connection with a large rolling mill installation.

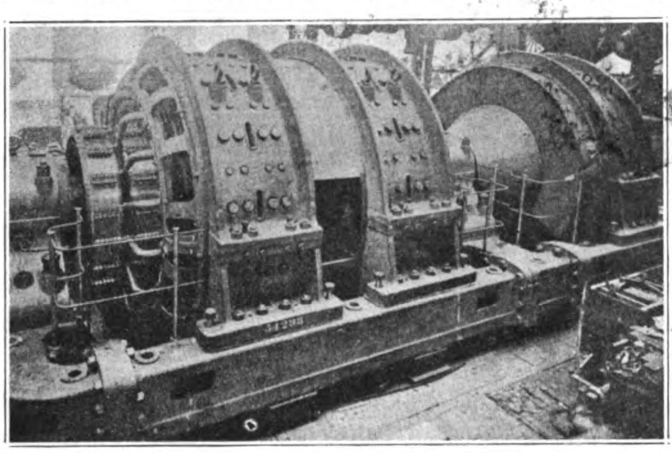


Fig. 1—19,000 hp reversing mill motor, showing three armatures mounted on a combined bedplate.

Turning to the details of the motor, attention may be directed to Fig. 2, which shows one of the armatures with the core plates built up, but before the windings have been placed in position. This figure also shows the central air gap and end plates which have been designed for providing ample ventilation. The main pole pieces are provided with a similar central gap, the gaps acting as a passage-way for the forced draught ventilation and providing an efficient means of cooling at the center of the compensating winding bars. The armatures are built up on cast steel spiders and are provided with independent shafts. The drive is transmitted through the spiders which are connected by special coupling pieces between the units. The couplings register the spiders and provide for a drive in either direction through special keys. These coupled spiders insure great rigidity and reduce deflection between centers to a minimum. Each armature is fitted with a double commutator. The three units, as will be seen from Fig. 1, are mounted on a combined bedplate.

As has already been said, the motor is capable of carrying a peak load of 19,000 hp at speeds from 60 rpm to 140 rpm in either direction. The pressure across the armatures is 1,400 volts, the diameter of the shaft in bearing is 24 in., and the shaft extension 27 in. The weight of the complete machine is approximately 300 tons. The motor generating set, which supplies power to the rolling mill motor, consists of a three-phase driving motor having a continuous rating of 3,750 hp on a 2,750-volt, 40-period, three-phase current, and runs at 400 rpm. This motor is directly coupled to, and is mounted on, the same bedplate with two variable-pressure generators, with a flywheel between them. The flywheel is of the built-up type, is 15 ft. in diameter and weighs 40 tons. As the mill is entirely controlled by varying the fields of the exciters supplying respectively the fields of the variable-pressure generators, and the mill motor, the main controller is of small dimensions.

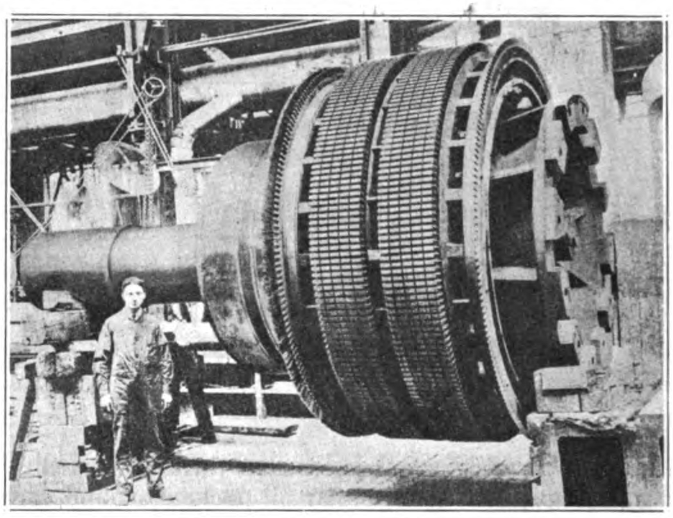


Fig. 2—One of the armatures of the motor with core plates built up, but previous to the windings having been placed in position.

Heating Furnaces and Annealing Furnaces

Examples Derived from Forge Furnaces — Heat Losses from Tongue-Hold, from Openings Around Ingot, Through Roofs Partly Burned and Through Incomplete Combustion.

By W. TRINKS.

PART V.

In Part IV the statement had been made that a great many different heat losses must be taken into account in order to make theory agree with practice. In the present installment some of these losses will be investigated numerically for the purpose of comparing their relative importance. A forge furnace will be selected as an example, because that type of furnace has many heat losses which can be avoided in other types.

A most prolific source of loss lies in the circumstance that, for a very large number of forgings, the ingot or billet must be heated in part only, one end sticking out of the furnace for a cold tongue-hold. All through the process of heating, heat flows from the part in the furnace to the stub which is outside, and is dissipated there by radiation and convection. Any attempt to determine mathematically the amount of heat thus dissipated meets with tremendous difficulties. We can write the differential equations of heat transfer easily enough, but we cannot integrate them, except by introduction of so many simplifying assumptions that the result is worth nothing. Then there remains the cut-and-try, point-by-point, numerical method, which is so tedious and slow that nobody uses it. In spite of all these difficulties, engineers want to know, at least approximately, what the heat loss through the cold tongue hold amounts to. A sufficiently close approximation can be made by investigating the heat flow during the soaking period, by which is meant the time, when the steady state has been reached. At that time, just as much heat is dissipated from the cold stub as flows into it from the heated portion in the furnace. During the early part of the heating period, the heat dissipation most certainly must be smaller, because the temperatures are lower. By comparison with tests we can then form a fraction by which the steady-state-heat-flow must be multiplied for the purpose of obtaining the average heat dissipation.

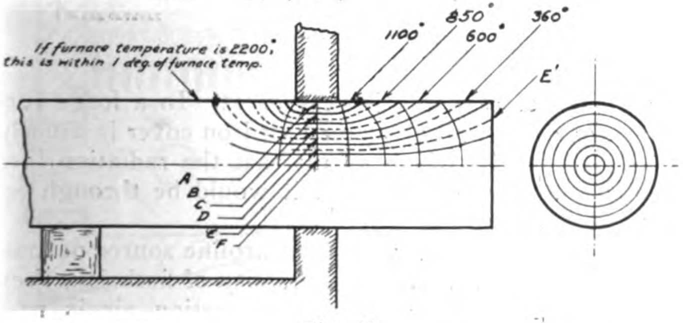

If furnace temperature is 2200°, this is within 1 deg. of furnace temp.
1100°
850°
600°
360°
E'
A
B
C
D
E
F

Fig. 33.

Fig. 33 will serve to illustrate the heat flow. The lines which, in the main, are horizontal, indicate the direction of flow of heat, while the lines which cross the flow lines at right angles are lines of equal temperature.

For purposes of calculation, the ingot was divided into a number of concentric layers. Each of the latter transmits as much heat as the length of the path and the temperature gradient permit. And as the length of the path of heat flow increases (from flow line A to flow line E) the temperature gradient drops, because the lowered surface temperature at the outcrop E of the flow line results in a lowered heat dissipation. A sample calculation will be found in the appendix to this installment.

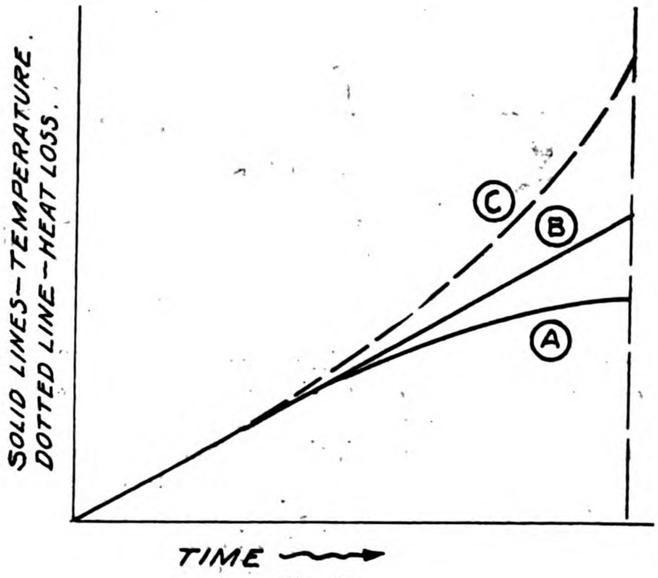


Fig. 34.

The resulting surface temperatures are marked in Fig. 33. It is evident that a fringe of red will be visible right at the furnace door. Likewise, the rates of heat dissipation in Btu per hour, corresponding to the surface temperatures, are shown. The total heat dissipation from a 34 inch ingot for the steady state is approximately 70,000 Btu per hour.

As stated before, the heat dissipation during the heating period is less than the rate of transmission in the steady state. The question is: How much less? For the answer study Fig. 34. From tests which I have made, I find that the temperatures at any given point of the stub projecting through the furnace door follow a law such as is expressed by curve A; that is to say, the rate of rise becomes less and less as the steady state is approached. This condition is exactly what was to be expected.

If temperatures had followed the straight line B, then the heat losses would have followed some curve, such as C; but since the actual curve of temperatures flattens off, the actual law of heat losses will, with sufficient accurate approximation, follow a linear equation. It is, therefore, permissible to take the average heat loss equal to one half of the steady-state-heat-loss.

But the calculation of the latter loss is far from being simple. It will not be used by practicing engineers, unless it is expressed by handy curves or else by a simple approximation. To find the latter, we can reason in this manner: The length of the projecting stub has not a very great influence. If the stub is short, the surface will be hotter, but there will be less surface which can radiate. If the stub is long, there will be more surface, but its average temperature will be lower. For that reason it appears permissible to replace the stub by an equivalent opening from which heat can radiate without obstruction. Ten per cent of the ingot cross section furnishes that equivalent opening. If, for instance, a round ingot of 20 inch diameter is being heated, the loss through the stump can be found by taking open radiation through 10 per cent of 314 = 31 square inches. From Fig. 24, the heat loss per unit of opening is known. Let the furnace temperature equal 2,200 degrees F., then the heat loss is 600 Btu per square inch and hour, or 18,600 Btu per hour.

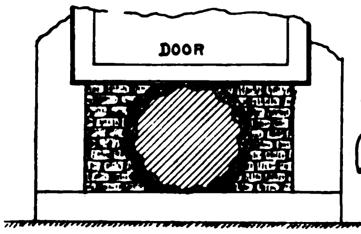


Fig. 36.

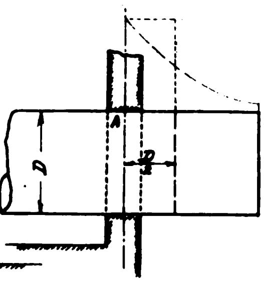


Fig. 35.

It should be noted that this method of calculation is only an approximation, but it will be realized that it is a very good approximation in view of the other uncertainties which surround forge furnace practice.

During the heating period, less heat is dissipated from the stub than is transmitted into it, on account of the thermal capacity of the stub. To find the amount of heat stored up in the stub end, replace it by an ideal stub of length ½ D, (see Fig. 35) projecting beyond the middle A of the door opening, and heated to ingot temperature.

A quite variable source of loss is radiation around the ingot. When the latter is first put into the furnace, bricks are set up on both sides, as indicated in Fig. 36. The laying of these bricks is never done carefully (unless the ingot is put into a cold furnace), because heat radiation does not permit the workmen to stay close to the furnace for any length of time. As a rule, the bricks are "dumped" with a long spade, and the cracks are smeared up with fireclay after a sufficient number of bricks have been put in place to permit work near the furnace. After the openings have been "mudded up," the temperature around the furnace is quite comfortable, first because the openings are sealed, and second, because the water in the fireclay is evaporating, which action absorbs heat. But, gradually, the clay dries, falls out, and the cracks open again, unless closed up immediately by more clay. It is, then, quite evident that the heat loss due to radiation around the billet or ingot depends upon operation. In cases of round ingots, wide doors, and very imperfect sealing, the unprotected area may equal 50 per cent of the cross sectional area of the ingot. Such negligence involves a tremendous heat loss.

Similar condition exists very frequently at the doors of forge furnaces. In taking an ingot out, furnacemen occasionally catch the door with the ingot, pull it away several feet from the furnace, and let it slam back, with the result that several bricks fall out. This happening leaves an unprotected opening, or else an opening which is imperfectly protected by ½ inches or ¾ inches of cast iron. The heat loss through a mere shell of cast iron is very great. In a forge furnace, the outer wall of such a cast iron cover is usually 1,300 degrees F., which means that the radiation loss is about 40 per cent of what it would be through an unprotected opening.

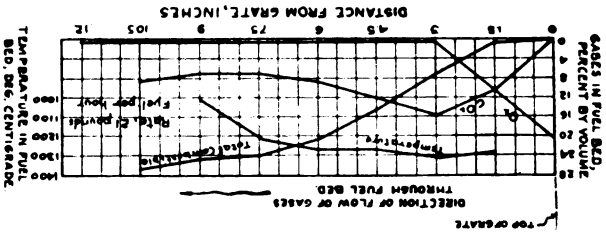


Fig. 37.

Roofs of forge furnaces are a prolific source of loss. Unless built of the very best quality of firebrick, they burn off, particularly if the combustion air is preheated, in which case even the best quality of firebrick is attacked. The roof gets thinner and thinner, until the high rate of heat transmission cools the layers immediately adjoining the inner layer to such an extent that the brick no longer changes its shape. From Fig. 20, page 136 of the March issue, it is evident that burning off causes the heat losses to go up by leaps and bounds. This loss is wholly independent of the loss which is occasioned by an opening in the roof. In forge furnaces, holes in the roof are caused quite often by missing the door and ramming the furnace with the ingot. A thin portion of the roof falls in, and the workmen say that the roof was "burnt out."

An additional, and by no means negligible loss of heat in forge furnaces occurs in many shops from the use of cold ingots. It is unwise to put a cold ingot into a very hot furnace, because cracks frequently develop, the outer skin lifting off the central core in spots. With cold ingots the precaution is frequently taken of cooling the furnace down to a dull red heat, before the ingot is charged. It is quite evident that this practice results in a very great heat loss, the

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amount of which varies with the quantity of brickwork cooled, and with the temperature to which the furnace is cooled down before charging. The loss can be overcome by charging ingots which are still hot from the open hearth, or can be partly overcome by the use of preheating pits.

Forge furnaces, like other heating furnaces, frequently lose much potential heat on account of incomplete combustion. This is particularly true of coal fired furnaces. Mr. Kreisinger of the Bureau of Mines, has shown that combustion of coal cannot be complete, unless air is admitted over the fire, or else by the admission of air through large holes in the fire. Fig. 37 shows the composition of the flue gases at different distances from the grate. It is quite evident that they leave the fuel bed laden with carbon monoxide and hydro carbons. If no air is admitted to the furnace, above the fire, all of the unburnt fuel goes up the stack, causing black smoke and frequently a flame at the top of the stack. The heat loss from the flue gas composition shown in Fig. 37 is 60 per cent of the heat value of coal.

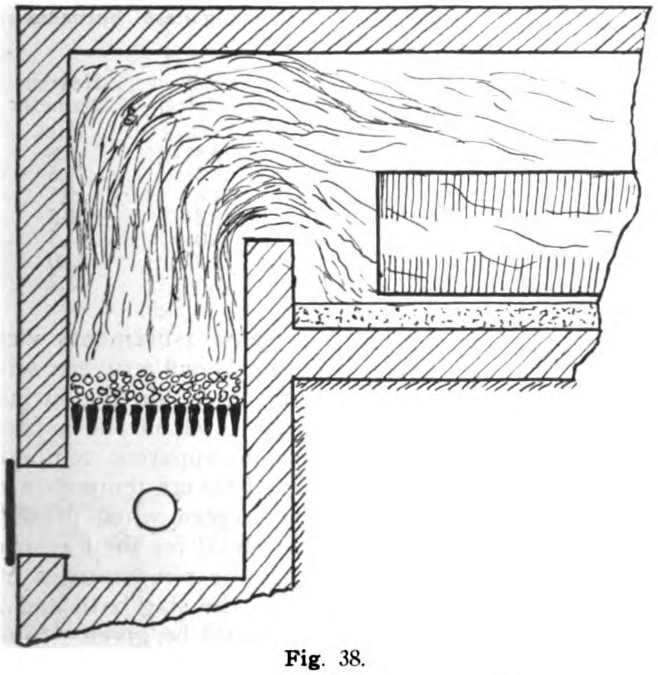

Fig. 38.

In forge furnace practice, the loss is not as great as indicated by this last figure, because large lump coal is used on the grate. In that case, air above the fire is admitted through the large openings between the lumps, and the loss is reduced, varying with the size of the lumps, and with the depth of the fuel bed, anywhere from 10 to 40 per cent.

While this figure constitutes a loss of considerable magnitude, there are cases on record with even greater losses which come about in this manner: In a coal fired furnace, such as shown in Fig. 38, the roof above the grate is exposed to extreme heat and burns off rapidly. (Note that the design of Fig. 38 is not to be recommended, but many furnaces of that type still exist.) To save the roof, steam is blown with air under the grate. This arrangement serves a twofold purpose. It puts the inside of the furnace under a slight pressure, preventing air from coming in and scaling the ingots or billets, and it keeps the fire from becoming too hot, thus saving the roof. But, while it serves both of these purposes, it causes additional fuel losses, because it converts the grate into a gas producer (semi-gas firing). To overcome this tremendous loss, we must admit secondary air, which, however, is omitted in some furnaces. The loss in that case depends upon the ratio of steam to air in the air supply to the grate.

The heat losses enumerated in this instalment are well known to every furnaceman. What I have aimed to do is to give sufficient data to enable engineers to weigh these losses numerically with a view to eliminating the worst of them.

Some can be eliminated by good furnace design, but others call for careful operation. And it is on the latter problem that so many forge plants fall down. As long as the heater furnishes sufficient ingots properly heated without scaling, everything is considered satisfactory, and the high fuel consumption is unfortunately taken into the bargain as a matter of course, or a necessary evil.

Finally, the high fuel consumption can only in part be relieved by regeneration or recuperation; that is to say, by preheating of the air needed for combustion, which fact will be instantly realized from the statement that air coming in through regenerators cannot be preheated by incompletely burnt fuel escaping around the furnace doors.

APPENDIX.

Example of Calculation of Heat Loss From End of Ingot.

Take section D, Fig. 33.

Length of path = 5½ ft.

Radiating area = 10 times conducting area.

(Note that conducting area also increases rapidly toward end of ingot.)

Heat conducted $\frac{30}{5\frac{1}{2}} = 5.4$ Btu per sq. ft. per deg. F. per hr.

Assume surface temperature at D′ is 350 deg. F.

Then heat radiated $= 10 \times (350 - 60) \times 3.80 = 11{,}000$. (From Fig. 18, previous installment).

Heat conducted $= 5.4 \times (2{,}200 - 350) = 10{,}000$. (1)

Actually, not as much heat is radiated from the ingot surface as from an equal area of furnace wall, because any spot cannot radiate through an angle of 180 degrees—its radiation is in part intercepted and returned by the furnace itself. Convection, however, is not affected. For D′, the relative radiation is probably 75 per cent. At this temperature, radiation is 60 per cent, convection 40 per cent of the total heat emission.

$(40\% + 75\% \times 60\%) \times 11{,}000 = 9{,}400$ . . . . (2)

Since (1) and (2) must be equal for the steady state, the actual temperature must be slightly higher —360 degrees F.

Blast Furnace Ferromanganese Production

Operating Data in Ferromanganese Practice — Control of Furnace Losses — Stack Losses — Burdening the Furnace. Accuracy of Result.

By P. H. ROYSTER

Something of a mystery has attached itself to the production of ferromanganese in the blast furnace. This alloy has been produced on the continent almost continuously since 1876 and in very considerable tonnages, but little definite information concerning the practice is to be found in technical literature, and almost nothing in the way of a theory of the manganese furnace. In this country prior to 1904, but one company had attempted its production in a serious way, and none of the operating data or other information from this company has been, or is, available to the public.

In the last five years, as a result of the restriction of imports, a number of furnaces have been blown in on this alloy, with the result that in 1918 as many as 18 furnaces were in blast. The majority of the men in charge of these furnaces had had little previous experience in such operations. Realizing the advantages both to the country and to the industry from a pooling of operating data and experiences, the Bureau of Mines in the summer of 1918, undertook the collection of data from ferromanganese furnaces. Although the results of this investigation have already been reported to the companies coöperating, they may be of permanent metallurgical interest, so this paper attempts to give, briefly, the more important points brought out in the investigations.

Operating Data in Ferromanganese Practice.

Operating data was collected by the bureau from 11 ferromanganese furnaces, which will be referred to throughout this paper as furnaces A, B, C, F, G, I, J, K, L, M, and P. The dimensions of seven of the furnaces are given in Table 1. The companies from which this information was obtained and to which should go the credit for whatever value this information may possess, are the Bethlehem Steel Company, B. & B. Trading Co., Buffalo Union Furnace Company, Donner Steel Company, John B. Guernsey & Co., Inc., E. E. Marshall, Miami Metals Company, Seaboard Steel & Manganese Corporation, Southeastern Iron Corporation, and the Wharton Steel Company.

The essential operating data is given in Table 2, presented in the form of 40 "runs" or experimental periods, each run being the average figures for 10 days continuous operation. It was intended, in selecting the 10-day periods, to cover as wide a range of operating conditions as possible, with due regard for the steadiness and constancy of the operation during the period. More accurate data would have been obtained from averages covering several months. It must be remembered, however, that averages taken over long periods suppress most of the variations in practice from which it was hoped to obtain information.

In addition to the figures taken from the furnace records, samples of downcomer gas were taken by the bureau at five furnaces, these samples being analyzed for O_2, CO_2, and CO. At six furnaces, supplementary temperature measurements were taken with Leeds & Northrup pyrometers. These measurements were made with the pyrometer sighted: Down a tuyere, with and without a tuyere glass interposed; on the surface of the slag at flush and at cast; and on the surface of the metal at cast. When the apparent temperatures are corrected, in the case of tuyere temperatures for the absorption of the glass screen when present, and in the case of the slag and metal for their respective emissivities,* a fair idea of the temperatures existing in the combustion zone, in the slag bath and in the metal bath of the furnace should be given. Since most of the data in Table 2 concerns furnace operation carried out before the visit of the bureau's field party, it is doubtful whether the gas analyses and temperature measurements taken by the bureau are strictly applicable to the average practice indicated in Table 2, but no better figures being available, these must serve.

Table 1—Dimensions of Ferromanganese Furnaces Investigated.

Furnace	Height, Stock Line to Center Line of Tuyeres, Feet	Bosh Diameter, Feet	Hearth Diameter Feet
A	62.1	13.4	8.8
B	55.0	16.5	9.5
C	66.2	14.8	9.5
F	57.8	15.2	10.5
G	63.0	18.0	11.5
J	67.4	18.3	13.0
K	63.0	18.6	13.2

Average Practice for Ferromanganese Furnace and for Iron Furnace.

Probably the most satisfactory method of discussing the ferromanganese furnace will be by comparing its figures to those of the iron furnace. A number of excellent descriptions of iron-furnace operation have been published, but it is doubtful whether a closer approximation has been made of the general practice obtaining in the larger modern iron furnaces than the following average figures collected by the bureau from nine of the largest plants in the country. No measurements of slag, metal, or combustion-zone temperatures on these furnaces were taken. The

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Paper read before A. I. M. E., contributed through the courtesy of the United States Bureau of Mines. Report of research under the joint auspices of the United States Bureau of Mines and the National Research Council.

* The emissivity corrections used are those given by Burgess, Technological Paper No. (191).

Table 2—Operating Data of Ferromanganese Blast Furnaces.

					Ore Analysis										Slag Analysis									
Experiment Furnace	Ore, Lb. per Ton	Coke, Lb. per Ton	Coal, Lb. per Ton	Stone, Lb. per Ton	Mn, Per Cent	Fe, Per Cent	SiO_2, Per Cent	Ton per Day	Slag, Lb. per Ton	Metal, Per Cent Mn	Metal, Per Cent Si	Blast Temp., Deg. F.	Top Temp., Deg. F.	Cu. Ft. Per Min.	CaO, Per Cent	MgO Per Cent	Al_2O_3, Per Cent	SiO_2, Per Cent	Mn, Per Cent	Carbon, Lbs.	Mn Charged, Lbs.	Per Cent to Metal	Per Cent to Slag	Per Cent Lost in Stack
1A	5981	4658	...	1980	41.18	4.54	7.78	45.7	2671	78.2	0.76	1308	935	12,870	27.2	9.7	13.0	27.8	14.6	3810	2462	71.2	15.8	12.9
2A	5303	5475	...	1780	39.11	6.65	5.64	37.2	2445	70.6	1.47	1268	1025	12,820	24.1	8.9	16.2	28.2	15.6	4440	2075	76.4	18.4	5.2
3A	5870	6290	...	1820	39.43	7.42	6.33	29.0	2805	71.3	0.92	1196	1049	.....	23.9	8.6	16.2	26.3	18.9	5360	2316	69.0	22.9	8.1
4A	6000	7133	...	2320	42.01	3.33	8.45	33.3	3035	80.9	1.24	1232	1054	.....	30.1	10.3	13.2	29.8	11.7	5820	2520	72.0	14.0	14.0
5A	5090	5016	...	1632	42.25	6.07	6.73	35.7	2248	73.5	1.24	1432	998	12,510	26.5	9.6	13.5	28.7	14.9	4060	2149	76.3	15.5	8.0
6A	5475	5628	...	1806	39.80	11.28	4.34	40.9	2180	69.4	0.73	1279	1147	.....	30.1	10.9	17.0	24.4	9.4	4560	2180	71.2	9.5	19.3
7A	5720	5595	...	1860	38.45	14.95	2.58	41.5	2070	68.3	0.85	1303	1103	.....	33.1	11.5	15.4	28.3	9.4	4480	2200	71.0	9.4	19.6
8A	6166	7352	...	2172	36.66	4.60	6.14	29.5	3335	78.3	0.70	1175	1014	.....	38.2	11.8	14.1	25.5	6.9	5992	2260	77.8	10.1	12.0
9A	6100	7836	...	2112	37.14	3.69	6.65	33.5	3460	80.35	2.20	1150	1015	.....	...	...	15.7	26.2	5.3	6380	2600	66.8	7.0	23.7
10B	7560	8070	...	2700	35.75	6.35	15.06	33.8	4630	72.34	0.62	786	....	.....	...	...	11.1	29.9	13.6	7080	2700	60.0	22.5	17.5
11B	6212	7776	...	2180	36.70	4.41	17.05	35.0	4110	77.13	0.58	770	....	.....	...	...	12.5	28.7	9.5	6810	2280	75.8	17.1	7.1
12B	7545	8435	...	2475	36.00	6.14	14.97	33.8	4460	72.88	0.74	886	....	.....	...	...	11.0	30.5	13.3	7400	2715	60.1	21.9	18.0
13B	6025	7534	...	2265	38.00	3.43	15.28	34.7	3670	77.7	1.43	782	....	.....	44.3	...	14.1	29.8	9.1	6600	2292	76.0	14.6	9.4
14B	8102	9510	...	3320	34.00	7.75	17.84	35.0	5745	74.5	0.58	830	....	.....	35.5	...	10.7	31.3	15.6	8340	2760	60.6	32.4	7.0
15F	7099	7539	...	3168	42.91	4.09	11.30	32.0	4100	76.3	0.37	735	757	14,380	28.4	6.5	11.1	29.1	19.8	6220	3045	56.1	25.6	18.3
16F	4813	6092	...	2091	43.68	6.71	6.87	44.9	2470	79.1	0.83	993	328	22.500	35.0	9.9	10.3	27.5	13.2	5030	2108	84.4	15.5	0.1
17F	4831	6431	...	2084	45.76	5.90	8.44	44.7	2610	78.8	1.12	1027	143	22,500	33.3	11.2	11.5	27.8	11.3	5310	2450	80.2	13.3	6.5
18G	7525	5400	546	2941	32.53	5.60	12.62	56.5	4600	78.2	1.53	1140	730	17,500	25.2	10.7	11.5	29.8	11.3	5140	2450	71.5	8.7	19.8
19G	6050	4855	459	2675	32.52	5.60	12.62	60.7	3765	67.5	1.61	1183	780	16,900	26.2	12.8	13.9	30.9	11.4	4565	1969	77.0	21.8	1.2
20I	8150	7282	...	3160	39.26	2.40	15.54	50.0	5040?	71.4	1.92	952	1016	17,100	26.6	14.1	15.2	27.7	11.4	5990	3200	52.7	18.0	29.3
21I	5850	4652	...	2165	41.64	5.54	7.43	82.7	2555	77.1	0.56	1277	934	16,500	31.4	12.6	11.3	26.5	12.0	3825	2435	71.0	12.6	16.4
22J	8560	6940	...	2510	43.83	4.00?	14.92	60.8	6230	69.1	2.05	1108	849	20,000	24.2	11.1	11.4	30.4	15.1	5550	2985	51.6	31.2	17.2
23J	5040	500	432	1278	44.73	4.06	2.60	94.1	2050	79.2	0.75	1156	496	15,900	26.0	8.9	24.2	21.7	8.1	4395	2258	78.7	7.4	13.9
24J	4900	2900	415	1264	45.20	3.80	2.53	70.0	2020	79.7	0.63	1237	....	20.000	27.3	7.1	23.5	21.3	13.3	4340	2226	80.3	12.1	7.6
25J	4960	4955	419	1255	43.75	4.18	2.86	97.9	1985	79.3	0.61	1172	562	19,500	27.9	7.1	24.5	20.9	12.1	4434	2168	81.6	11.1	7.3
26K	4040	6275	...	1985	50.65	7.27	6.52	46.9	2190	75.9	2.43	950?	....	.....	46.4	1.7	14.7	27.3	5.4	5420	2048	83.0	5.8	11.2
27K	4480	5802	...	2268	51.13	7.10	5.35	85.8	2580	74.8	0.29	790	965	17,500	37.1	1.1	11.4	28.8	14.3	4690	2288	73.1	16.2	10.7
28K	4650	6368	...	2184	50.11	7.30	5.57	49.5	2315	75.9	1.82	950?	....	.....	46.6	1.5	13.8	27.6	5.7	5450	2030	73.0	5.7	21.3
29K	5215	6329	...	2386	46.94	10.80	6.24	77.5	3285	62.5	0.26	998	845	19.100	33.3	1.4	11.1	26.5	19.6	5280	2442	57.2	26.3	16.5
30L	6770	7458	660	2965	39.97	3.51	7.53	48.1	3126	80.7	1.29	1065	1162	17,800	40.3	6.8	11.7	31.1	8.8	6730	2710	66.9	10.3	22.8
31L	6565	8459	747	3100	39.68	3.69	7.40	43.0	3305	81.1	1.47	1043	1152	17,700	47.7	5.7	12.8	27.4	4.6	7655	2608	69.7	5.9	24.4
32L	5312	6500	524	2582	35.45	9.54	8.91	64.7	2886	69.8	0.75	1089	1162	18,800	42.0	5.6	11.8	29.9	7.2	5951	1888	82.8	10.1	7.1
33L	6222	6421	424	2588	35.38	4.50	6.28	50.5	2727	78.4	2.72	1204	1127	17.800	43.3	4.3	14.5	27.3	6.9	5651	2200	79.7	11.1	9.2
34L	5465	4855	471	2200	32.38	8.02	10.11	77.2	2452	70.4	1.46	1457	1123	18,800	41.9	6.3	10.5	31.6	5.8	4432	1890	89.0	8.1	2.9
35L	5200	5164	352	2155	33.53	7.81	8.63	77.1	2256	71.8	2.23	1207	1140	18,800	44.3	4.9	13.2	31.0	4.4	4568	2690	92.1	8.7	0.8
36P	7000	5350	545	3591	38.70	4.25	15.89	61.3	4468	78.1	...	1450	750?	.....	41.0	...	14.9	35.4	4.5	5060	2718	64.5	6.4	29.1
37P	4117	4965	506	1680	45.50	5.55	4.85	78.0	1880	80.9	...	1450?	750?	.....	45.6	...	18.8	20.3	9.9	4700	2060	88.0	4.9	7.1
38C	5245	5704	811	2773	40.70	7.45	7.01	35.0	2700	74.9	2.19	1387	952	.....	29.8	18.2	10.7	32.2	7.3	5280	2138	78.7	8.9	12.3
39M	6586	7118	908	3042	45.11	3.66	6.59	42.0	3900	75.7	1.20	1242	905	.....	38.8	...	14.4	25.7	15.2	6500	2970	57.1	20.0	22.9
40M	6598	7100	957	3510	46.36	4.15	4.08	36.8	3480	74.5	1.30	1182	910	.....	43.3	...	11.1	28.7	11.8	6471	3056	54.5	13.4	32.1
Average	5992	6326	200	2349	40.33	5.93	8.60	51.7	3196	74.9	1.15	1135	690	.....	Base 41.75	...	14.0	28.1	10.6	5523	2382	72.0	14.6	12.8

average of the measurements by Linville,[*] Johnson,[†] and Feild[‡] and unpublished measurements made by the bureau at some eight iron furnaces are taken as the nearest approach to an estimation of these temperatures. A comparison of the more important figures for the two practices is given in Table 3. The important differences noticeable in this comparison are that the ferromanganese furnace received about three times as much coke and over twice as much stone as the iron furnace, lost over five times as much carbon by CO_2 absorption, operated with a hotter top and a colder combustion zone, produced colder metal and slag, and produced gas with a CO/CO_2 ratio two and a half times as great. The points of similarity are that the blast temperatures were roughly the same, and the slag compositions were essentially the same if the dilution of the ferromanganese slag with MnO is ignored.

These points of difference and of similarity are due to the operation of the furnace. In addition, there are differences due to the nature of the materials used and of the metals to be produced. All of the iron charged which is not blown from the top of the furnace as dust—amounting apparently to 9.6 per cent[§]—is recovered in the metal. Of the manganese charged in the ferromanganese furnace, however, only 72 per cent finds its way into the metal; about 15 per cent of it being carried away unreduced in the slag and 13 per cent being carried out at the top of the furnace with the gas, a loss that will be called, for convenience, the stack loss.

Control of Furnace Losses.

There are no silicon specifications to be met in the making of ferromanganese; the sulphur from the coke is taken care of as MnS in the slag, and, due to the large amount of coke in the charge, the stock is "loose," descending easily in the furnace without hanging or slipping. The operating difficulties, therefore, resolve themselves practically into the problem of keeping down the slag and stack loss. According to generally accepted ideas, the slag loss is reduced by operating with a highly basic slag, with a hot blast, and with plenty of coke. The results of the present investigation substantiate these ideas in a general way but carry them forwards from the realm of qualitative ideas and place them on the basis of a quantitative relationship. The question of stack loss has proved more difficult. According to these generally accepted ideas, the stack loss is supposed to increase in a vindictive sort of way whenever the slag loss is reduced. In particular, it is supposed to increase with the hearth temperature, with the basicity of the slag, and with the temperature of the top gas. The evidence offered by this investigation fails to support any of these theories; fails, in fact, to show any marked relationship between the stack loss and any other probably related quantity. The problems connected with the determination and the control of these two losses will be discussed in the two following sections.

Table 3—Comparison of Operating Data for the Ferromanganese Furnace and for the Iron Furnace.

		Ferromanganese	Pig Iron
1	Ore per ton metal, lb	5,992	3,937
2	Coke per ton metal, lb	6,326	1,969
3	Coal per ton metal, lb	200	0
4	Stone per ton metal, lb	2,349	984
5	SiO_2 in ore, per cent	8.6	7.55
6	Al_2O_3 in ore, per cent	3.0*	1.96
7	Fe in ore, per cent	5.9	52.41
8	Mn in ore, per cent	40.3	0.61
9	SiO_2 in coke, per cent	6.5*	4.98
10	Al_2O_3 in coke, per cent	3.0	3.25
11	F. C. in coke, per cent	85.5	87.64
12	SiO_2 in stone, per cent	....	3.33
13	Al_2O_3 in stone, per cent	....	1.28
14	CaO in stone, per cent	52.0	48.20
15	MgO in stone, per cent	52.0	3.64
16	C in metal, per cent	6.5*	3.80
17	Si in metal, per cent	1.15	1.33
18	Fe in metal, per cent	17.0	93.85
19	Mn in metal, per cent	74.9	0.87
20	S in metal, per cent	0.01*	0.036
21	CO_2 in gas (by weight) per cent	10.44	19.86
22	CO in gas, per cent	31.00	23.57
23	H_2 in gas, per cent	0.17*	0.17
24	CH_4 in gas, per cent	0.21*	0.21
25	N_2 in gas, per cent	58.36*	56.16
26	SiO_2 in slag, per cent	28.1	36.14
27	Al_2O_3 in slag, per cent	14.0	13.33
28	CaO in slag, per cent	41.7	43.59
29	MgO in slag, per cent	41.7	4.50
30	Mn in slag, per cent	10.6	0.53
31	S in slag, per cent	...	1.49
32	Slag volume, lb	3,196	1,150
33	Blast temperature	1,135°F.	1,031°F.
34	Top temperature	690°F.	400°F.
35	Temperature combustion zone	2,740°F.	2,812°F.
36	Temperature of slag	2,515°F.	2,740°F.
37	Temperature of metal	2,435°F.	2,740°F.*
38	Wind per ton metal, lb	24,000	8,012
39	Gas per ton metal, lb	31,610	10,634
40	Metal per day, tons	51.7	499
41	C burned at tuyeres	4,165	1,386
42	C absorbed by CO_2	946	169

*Estimated.

Slag Loss.

The most self-evident statement to be made concerning slag loss, but the one that actually is seldom stated and often is forgotten, is that the pounds of manganese carried away by the slag equals the product of the slag volume and the percentage of manganese in the slag. The percentage of manganese in the slag is a physical quantity. Although perhaps it is not actually something green that can be seen, it is at least a quantity that the chemist reports every day. The product of this quantity multiplied by the slag volume (a figure the furnace operator works out probably once a year) is rather abstract and does not appear on the furnace records. In consequence, a low percentage of manganese in the slag has grown to be something of a commonly accepted criterion of good practice. Where the manganese content of the slag is reduced as a result of high blast temperature or by slow driving, it is a satisfactory guide. But if it is reduced by the addition of coke, especially a high-ash coke, the increase in slag volume may outweigh the advantage of a reduction in the manganense percentage of the slag with the result that the actual weight of manganese in the slag is greater.

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[*] C. P. Linville: Combustion Temperature of Carbon. Trans. (1910 41, 268.

[†] J. E. Johnson, Jr.: Notes on the Physical Action of the Blast Furnace. Trans. (1906) 36, 454.

[‡] A. L. Feild: The Viscosity of Blast-furnace Slag. Trans. (1916) 56, 633.

[§] In addition to the Fe in the ore given in Table 3, the iron furnace received an average of 176 lbs. (79.8 kg.) of mill-scale and 63 lbs. (28.5 kg.) of scrap per ton of pig. The iron in the slag is negligible; 5 lbs. (2.3 kg.).

Therefore, the first step in the problem of reducing the slag loss is to find a means of determining in advance the percentage of manganese in the slag, whatever value it may have, rather than to find by what means it may be made a minimum. The following attempt has been made to find a quantitative expression for this quantity:

Let M = percentage of manganese in slag;
B = ratio of $(CaO + MgO)\ SiO_2$ in slag;
R = pounds of gross slag made per minute per square foot hearth area;[*]
T = blast temperature, in degrees F.;
V = slag volume, in pounds per ton of metal;
K = pounds of carbon in fuel per ton of metal.

The results of the 40 runs were plotted, first with pounds of carbon charged as ordinates and blast temperatures as abscissas, and second, with pounds of carbon charged as ordinates and slag volumes as abscissas. Through the points the two best straight lines were drawn, and from the slopes of these lines the variation in carbon fuel with blast temperature and with slag volume was determined. It was found that:

$$\left.\frac{dK}{dV}\right| T = \text{const.} = 0.88$$

and that

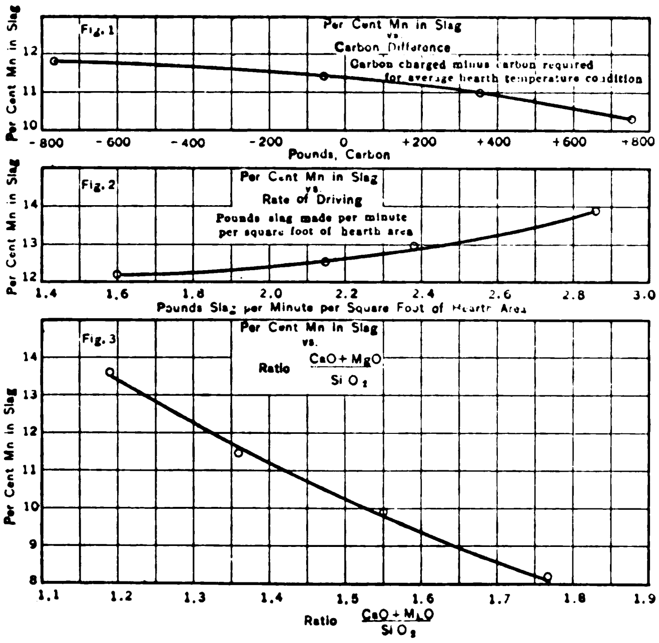
$$\left.\frac{dK}{dT}\right| V = \text{const.} = -1.33$$

hence, integrating these two formulas and determining the constant of integration

$$K_a = 4170 + 0.88\ V - 1.33\ T \qquad (1)$$

That is, if for every degree increase in blast temperature the carbon is reduced 1.33 lb. (0.6 kg.) and for every pound increase in slag volume the carbon is increased 0.88 lb. (0.4 kg.), the hearth temperature conditions will remain constant.[†] It does not mean that the operator must increase the carbon charged 0.88 lb. for every pound increase in slag volume. Since usually the man burdening the furnace does not know what the slag volume is and does not admit that the figure 0.88 is correct, such a contention would be absurd. K_a in formula 1 is merely the carbon required with a given blast temperature and a given slag to maintain the average temperature conditions in the hearth. If he wishes, the operator can reduce the carbon charged until the hearth almost freezes or he can charge so much carbon that he bankrupts the owners, and the furnace will still make ferromanganese, even if it does not make money.

The value of K_a was worked out by means of formula 1 for each of the runs in Table 2, and the expression $K - K_a$ determined. This expression gives the excess or deficiency of the actual carbon charged above or below that required for average hearth temperature conditions, and will be called the "excess carbon." In the absence of pyrometer readings, it is the best guide to the temperature of the hearth. To show the relation existing between the percentage of manganese in the slag, the hearth temperature, the speed of operation, and the basicity of the slag, a similar procedure was adopted.



Figs. 1, 2, 3.

The figures in Table 2 were arranged, first, in order of decreasing "excess carbon" $(K - K_a)$; second, in order of decreasing "speed of slag formation," and third, in order of decreasing slag basicity $(CaO + MgO/SiO_2)$. Each of these series was broken into four groups and the various figures averaged by groups. The results appear in Tables 4, 5, and 6. The significance of the first five columns is self-evident. The manganese in the slag is seen to be a function of three variables. In order to determine the effect of a change in one of these variables while the other two remain constant, it was necessary to apply the method of successive approximation. This somewhat tedious method shows that:

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[*] Gross slag means the total weight of slag-forming materials, manganese being a slag-forming material. The evidence at hand points strongly to the conclusion that the MnO is reduced in the hearth. Therefore the pounds of this gross slag—a basic manganese aluminosilicate—formed per minute per square foot of hearth area is the best measure of the speed of operation. This rate of slag formation is given throughout in the unit of pounds per minute per square foot of hearth area.

[†] It must not be thought that K_a and K are two different variables, they are but two values of the same variable. K_a is not an operating quantity of the furnace, it is the carbon fuel that the furnace would receive if it were given the average fuel relative to its slag volume and blast temperature. If the actual fuel charged is more than K_a, it will cause the hearth to operate at a higher temperature; if it is less than K_a, the hearth will be at a lower temperature than the average. In fact $(K - K_a)$ is an arbitrary temperature scale, although it is not possible to connect its values with the thermometric scale.

$$(a)\quad \frac{dM}{d(K-K_a)} = 0.0011 \text{ if B and R constant}$$

$$(b)\quad \frac{dM}{dR} = 1.34 \text{ if B and } (K-K_2) \text{ are constant}$$

$$(c)\quad \frac{dM}{dB} = -9.16 \text{ if R and } (K-K_a) \text{ are const.}$$

Integrating the three formulas and determining the constants of integration,

$$M = 10.6 - 0.0011\ (K - K_a) + 1.34\ R - 9.16\ B \quad (2)$$

Combining formulas 1 and 2, and multiplying the result by V,

$$\text{Slag loss} = MV = 15.2 + 1.34\ RV - 0.0011KV + 0.00088\ V^2 - 0.00133\ TV - 9.16\ BV \quad (3)$$

The meaning of the last column in Tables 4, 5, 6, will now be apparent. In Table 4, the relation between M and $K - K_a$ is to be shown, but the values of B in the third column and R in the fourth column are not constant. The actual change is due largely to the change in $K - K_a$ but to some extent to changes in B and R. The value of M for each group of runs is therefore reduced according to the relation (b) for changes in R and according to (c) for changes in B. The values of M given in the sixth column show the relation between M and $(K - K_a)$ alone, R and B being constant. The numbers in the first column of Table 4 are used as abscissas in Fig. 1, and the reduced values of M in the sixth column are used as ordinates. The results from Tables 5 and 6 are reduced in the same manner and plotted in Figs. 2 and 3.

Table 4—Variation of Per Cent Mn in Slag With Excess Carbon.

Group of Runs	Excess Carbon, Pounds	Ratio Bases SiO_2 in Slag	Rate of Slag Formation	Mn in Slag, Actual Per Cent	Mn in Slag, Reduced Per Cent
1	+754	1.69	1.84	8.2	10.3
2	+354	1.48	1.92	11.0	11.0
3	— 56	1.45	2.18	12.1	11.4
4	—765	1.37	2.36	13.3	11.8

Table 5—Variation of Per Cent Mn in Slag With Rate of Slag Formation.

Group of Runs	Rate of Slag Formation	Ratio Bases SiO_2 in Slag	Excess Carbon, Pounds	Mn in Slag, Actual Per Cent	Mn in Slag, Reduced Per Cent
5	2.86	1.38	— 60	13.0	13.9
6	2.38	1.70	—312	12.0	12.9
7	2.15	1.51	— 62	12.6	12.5
8	1.60	1.64	+240	10.3	12.2

Table 6—Variation of Per Cent Mn in Slag With Basicity.

Group of Runs	Ratio Bases SiO_2 in Slag	Excess Carbon, Pounds	Rate of Slag Formation	Mn in Slag, Actual Per Cent	Mn in Slag, Reduced Per Cent
9	1.77	+411	1.79	7.4	8.2
10	1.55	+187	2.06	9.2	9.9
11	1.36	— 10	2.32	11.8	11.5
12	1.19	—110	2.42	14.2	13.6

The method for determining the formula for slag loss (formula 3) is admittedly rather involved, but this is due rather to the complexity of the relations involved than to the method of attacking the problem. The experimental errors throughout are very great; it is hoped, however, that by basing the formula on the average of a number of runs from a number of different furnaces, the effect of the errors is minimized. The correctness of the formula must be judged by the points plotted in Figs. 1, 2, and 3. The relation between M and the four independent variables K, B, R, and T is assumed to be linear, and it is seen that in each of the figures a straight line can be drawn which will pass within 0.5 per cent of the actual value of M. The uncertainty in the value of the various quantities involved makes this much within the known experimental error.

Stack Loss.

The 40 runs of Table 2 were divided into two groups according to the values of the stack loss for each run and the averages of these two groups are given in Table 7. Although the difference between the stack losses for the two groups of runs involves 14 per cent of the total manganese charged, there is no noticeable relationship between it and the other figures given in the table. With high stack loss, the top temperature is 6 degrees F. less, the Mn in the slag is but 0.4 per cent greater, the Si in the metal 0.09 per cent greater, and the basicity ratio 0.02 per cent greater. Hence none of these quantities apparently can be responsible for the great difference in stack loss. A difference in the right direction appears in the case of excess carbon; the high-stack-loss operation carries relatively 103 lb. (46.7 kg.) more carbon and since the average carbon charged is over 5,000 lb. (2,268 kg.) this 103 lb. is about 2 per cent of the total. In the first place, since coke is charged by volume and not by weight, the least imaginable error in evaluating its weight will be more than 2 per cent; further, if this difference in fuel is to account for the difference in stack loss, it must be concluded that 700 lb. (317.5 kg.) of excess carbon would cause the stack loss to be 100 per cent. The two values for the rate of slag formation are so nearly identical that this quantity can scarcely be a factor in the problem.

Table 7—Averages of Two Groups Formed From Runs of Table 2.

	Operation with high stack loss	Operation with low stack loss
Stack loss, per cent..........	20.0	6.5
Top temperature, degrees F..	924	930
Mn in slag, per cent.........	11.3	10.9
Silica in metal, per cent......	1.19	1.11
Ratio of bases to silica.......	1.54	1.52
Excess carbon	+83	—20
Rate of slag formation......	2.24	2.09

It should be remembered that the stack loss is the result of a computation involving four weights and ten chemical analyses, and further, that the nature of the computation is such that any errors in the determination of these 14 quantities accumulate. It is clearly demonstrated, it would seem, that more accurate data is needed on this point. In the absence of better information, it must be taken as a working hypothesis that the stack loss is not increased by a hot top, a basic slag, fast driving, or a high coke consumption. It is possible, of course, that the cause of stack loss has been overlooked entirely in this discussion, or that by some coincidence the errors have so arranged themselves as to mask the true result.

Burdening the Furnace.

If this conclusion concerning the stack loss is accepted, formula 3 will be sufficient for determining in advance from the charge sheet the results to be expected from the furnace. Casual examination of Figs. 1, 2, and 3 will make it apparent that the reduction of the per cent Mn in the slag by using excess carbon, or even by using the average carbon will hardly pay for itself. It would seem that in general the coke used has been more than was profitable. Also, the rate of driving has been too low, at least from the standpoint of furnace profits. The most effective method of reducing the slag loss is by carrying a highly basic slag. In nearly every case a ratio of bases to silica in the slag as high as 2.0 is practicable. This is 0.52 higher than the average basicity, 1.48 actually obtaining in the 40 runs. Formula 2 shows that an increase of 0.52 basicity will lower the percentage of Mn in the slag 4.77 per cent; the addition of stone necessary to attain this basicity will increase the slag volume from 3,196 to 3,656. The manganese carried away in the average practice recorded is 10.6 × 3,196, or 338 lb. (153 kg.). With a basicity of 2.0, the manganese in the slag would be 5.83 × 3,656, or 213 lbs. (96.6 kg.). The saving due to the change is 125 lbs. (56.6 kg.) per ton of alloy, or about 5.25 per cent of the manganese used. When the alumina content of the ore is high, it is possible to operate with a slag having a basicity of 2.5 or greater; in this case it is possible to bring the per cent Mn in the slag down to 1.5 or 2.0 per cent.

The saving possible by changes of practice, while appreciable, are very much less than that resulting from the proper choice of materials. It can be shown, in fact, that by the use of low-silica coke and stone, the profits of the furnaces could have been doubled, and this with a saving of 9 per cent of the ore and 38 per cent of the coke used, and with a 50 per cent increase in furnace capacity. It has been suggested that great advantages are to be derived from a high blast temperature. The average blast temperature in Table 2 is 1,136 degrees F. (613 degrees C.). It might be feasible to bring this average temperature up to 1,700 degrees F. (927 degrees C.). According to formula 1, this would lower K_a 750 lbs. (340 kg.) of carbon, or 13.5 per cent. The average run, however, could stand a deficiency of 750 lbs. of carbon with an increase of only 0.83 per cent in the manganese content of the slag, or a loss of about 1.1 per cent of the manganese in the ore charged. This saving would undoubtedly be out of proportion to the trouble and expense needed to increase the blast temperature to 1,700 degrees F.

Accuracy of Result.

As to the question of how much confidence should be placed in the results of this investigation, it must be remembered that the operating data recorded here is in general less reliable than would be expected by one acquainted only with iron-furnace practice. There are two reasons for this: (1) Manganese ores are extremely variable in character and in chemical composition. The difficulty of assigning a strictly representative analysis to the manganese-ore mixture charged on a given day is very great. Accurately to keep track of this one item would entail an amount of labor and expense that no furnace would be justified in incurring until it had been demonstrated that the resultant information would pay for itself. (2) Most of the manganese-furnace operations included in this investigation were undertaken and carried out at a time when it was impracticable to maintain the clerical force and the chemical laboratory required to keep perfectly satisfactory furnace records. It was a time, too, when the coke delivered at the furnace was becoming increasinly variable in composition.

Where relationships have been worked out, however, based on the average figures from a number of different furnaces, there is a tendency for any errors present to neutralize each other. It is reasonable to suppose, therefore, that the results given above are in general correct. That the results, if true, would be worth over $20,000,000 annually to the manganese-furnace industry means only that such an investigation was needed; the fact that they may be untrue means only that a more complete investigation is needed. The writer's purpose in working out these relationships was, in fact, largely to show the nature, extent, and value, of the results that can be obtained from an investigation of this kind.

EDITOR'S NOTE—It is of interest to note here that C. M. Weld, of the Bureau of Mines, reviewed the manganese situation, in the War Minerals Series No. 7, during the latter part of last year. The work done by the Bureau of Mines has been of valuable assistance as shown by its policy as set forth in the above mentioned bulletin: In the past the United States has imported practically its entire manganese supply. When this country entered the war, the shortage of ships and the pressing need for ships for military purposes made it imperative to procure our supplies as far as possible from within our own borders. In this connection it became the duty of the Bureau of Mines to make a close study of the situation.

Two lines were followed. 1. With the full coöperation of the United States Geological Survey, all possible domestic sources of supply were investigated, and wherever possible advice and help were given in connection with mining and milling problems. 2. The manufacture of the manganese alloys and the use of these alloys in the manufacture of steel were carefully studied with a view to conservation.

At the same time patriotic motives and high prices combined to apply a powerful stimulus to the industry. The results have bee nso satisfactory that today this essential mineral has ceased to give concern to the government.

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Proper Lubrication of Air Compressors

Heat of Compression—Periodical Cleansing of System—Cleaning Air Receiver and Piping—Asphaltic-Base Lubricating Oils. Proper Quantity of Lubricating Oils—Qualities of Cylinder Oils.

By **H. V. CONRAD.**

Satisfactory lubrication of air compressor cylinders is attained by securing (1) the reduction of friction to a minimum and (2) elimination of carbonization of the oil as far as possible.

For the proper reduction of friction, the oil chosen should have sufficient body to sustain the weight of the moving parts and to form a seal between the piston rings and the cylinder walls, and still not absorb excessive power in the overcoming of the viscosity of the oil itself.

The objections to air cylinder oils which allow more than the very slight amount of carbonization which appears unavoidable, are of course, well known but may be briefly stated for the purpose of clarifying what follows:

Carbonization of the oil allows the accumulation of deposits of carbon which are sticky in the early stages of their formation but hard and flinty later. Such deposits accumulate on the cylinder valves, in the cylinder passages, in the pipes and eventually in the air receiver.

Sticking or partial closing of the valves and their consequent failure to act properly is probably the chief objection to this action from the standpoint of the efficient operation of the compressor.

The formation of excessive carbon deposits is apt to be due to any one or more of the following causes:

1. The ill-advised use of some oil, such as a steam cylinder oil, which easily decomposes in the heat of the air cylinder.
2. The use of oils of too great a viscosity—commonly referred to as "too heavy oils." These do not atomize readily and, therefore, remain too long upon the hot cylinder walls, etc., thus baking down to sticky carbon deposits.
3. The use of too great quantities of oil which has the same effect as the use of too heavy an oil as far as the carbonization is concerned.
4. The failure to provide a proper screen over the air intake of the compressor, thus allowing free entrance of dangerous dust (especially coal dust).

The objections to this carbonization aside from the sticking of air valves and choking of the air passages is the menace of fire entailed by carbon deposits. Carbon particles torn loose from them may become incandescent from causes which could not be anticipated by the compressor manufacturer. If such incandescent carbon particles should happen to come in contact with "oil vapor" given off by the lubricating oil, a fire might possibly be started whose menace would be small or large depending upon how much carbon had been allowed to accumulate in the compressor and piping to the receiver. If these are kept properly cleansed at all times, there should never be a time of any danger.

This oil vapor is given off from a lubricating oil at a certain temperature called its "flash point" just as steam arises from water at a certain point.

Heat of Air Compression.

The selection of an air cylinder lubricant is, of course, governed to a considerable extent by a knowledge of cylinder temperature it must withstand. Knowing the air pressures, the corresponding temperatures are ascertained fairly accurately, as shown in Table No. 1.

This table gives the final temperature in the cylinder at the end of the compression stroke, for single stage, also for two stage (or compound) compression, when the free air entering the cylinder is 60 degrees F.

Table No. 1—Cylinder Temperatures at End of Piston Stroke.

Air Compressed to	Final Temperature Single Stage	Final Temperature Two Stage
10 lbs. gauge	145 degrees F	
20 lbs. gauge	207 degrees F	
30 lbs. gauge	255 degrees F	
40 lbs. gauge	302 degrees F	
50 lbs. gauge	339 degrees F	188 degrees F.
60 lbs. gauge	375 degrees F	203 degrees F.
70 lbs. gauge	405 degrees F	214 degrees F.
80 lbs. gauge	432 degrees F	224 degrees F.
90 lbs. gauge	459 degrees F	234 degrees F.
100 lbs. gauge	485 degrees F	243 degrees F.
110 lbs. gauge	507 degrees F	250 degrees F.
120 lbs. gauge	529 degrees F	257 degrees F.
130 lbs. gauge	550 degrees F	265 degrees F.
140 lbs. gauge	570 degrees F	272 degrees F.
150 lbs. gauge	589 degrees F	279 degrees F.
200 lbs. gauge	672 degrees F	309 degrees F.
250 lbs. gauge	749 degrees F	331 degrees F.

Variations from these temperatures will occur in actual practice due to water jacketed air cylinders and radiation, tending to lower the temperature at the high pressures. But at, say, 50 pounds pressure and lower, the heat is likely to be somewhat greater than given by the table, particularly if the compressor is run at high speed and also if it is not water jacketed.

Relation of Oil Flash Point to Cylinder Temperature.

The natural inference of the reader after noting the temperatures in Table 1, is that he must select an air cylinder oil whose flash point is higher than the maxi-

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Paper read before Compressed Air Society, New York.

mum temperature apt to be encountered within the air cylinder. As a matter of fact, this is not the case and it need only be carefuly noted that: the study of the air cylinder temperatures is useful mainly in testing lubricating oils to determine their resistance against breaking down into carbon, etc. But such temperatures cannot be taken as limits establishing the highest allowable flash point for a lubricant safe to use in the air cylinders.

Qualities of Cylinder Lubricating Oils.

For average normal conditions, the oil should be a medium bodied pure mineral oil of the highest quality, not compounded with fixed oils such as animal or vegetable, and should be carefully filtered in the final proces of manufacture.

Quite a range of oil composition is permissible for lubricants approved for this work, which are manufactured under the above conditions. Primarily a distinction must be made between those oils having a paraffin base as distinguished from those having an asphaltic base.

From a strictly operating standpoint—so it is claimed by some lubricant manufacturers—there is no distinction between these two classes of lubricants as to their desirability as compressor cylinders oils, provided that both have been properly filtered in the process of manufacture to remove the carbon forming elements. If any carbon should be formed, however, such carbon deposited by the asphaltic base oils is of a light fluffy nature and easily cleaned out, whereas, that deposited by the paraffin base oil is very adhesive, and characterized by the hard, flinty nature.

Paraffin Base Lubricating Oils

Merely as a guide to aid the operator in specifying the qualities to be posessed by an air cylinder lubricant recommended for average duty, the following table is presented:

Table No. 2—Physical Tests of Paraffin Base Oils.

	Minimum	Average	Maximum
Gravity, Baume....	28 to 32°	25 to 30°	25 to 27°
Flash Point, Open Cup	375 to 400° F.	400 to 425° F.	425 to 500° F.
Fire	425 to 450° F.	450 to 475° F.	475 to 575° F.
Viscosity (Saybolt) at 100° F.........	120 to 180 sec.	230 to 315 sec.	to 1500 sec
Color	Yellowish	Reddish	Dk. Red to Green
Congealing Point (pour test deg. F.)	20 to 25° F.	30° F.	35 to 45° F.

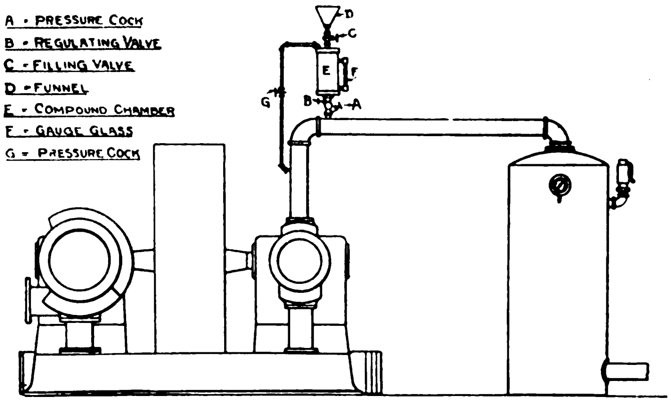
It is suggested that those oils within the range expressed by the minimum figures be used for light duty of low-pressure and temperatures, while those expressed by maximum figures should be used for high pressures and temperatures.

It is recommended that any paraffin base lubricant intended for use in "all standard air compresors," should meet the physical tests imposed by the average range of figures given in the middle column of the above table. The above wording "standard air compressors" is to be interpreted as including the following types of machines:

a Low pressure up to 100 lb. compressors, which may be either small sized single stage units, or larger sized compound machines.

b High presure compressors which are constructed with the proper number of stages so that no excessive temperatures are ever reached.

In other words, this lubricant of average test figures is always recommended unless a compressor manufacturer specifies in his literature that a high flash point oil should be used to meet the conditions peculiar to his machine. It is thus obvious that it is never necessary that a lubricant should possess a flash point as high as 500 degrees unless abnormal conditions of high temperature prevail. Such high flash point oils have an unusual tendency to produce carbon deposits.



Device for cleaning carbon in air discharge line and receiver of air compressors.

Compound—Mix 1 lb. of Red Seal lye to 18 lbs. of water.

To Use Compound—Close cock A and G, open valve C and fill compound through funnel D, when chamber E is filled close valve C, open cock G and A and regulate feed by valve B. Use about 70 drops per minute.

Asphaltic-Base Lubricating Oils.

This group of oils is considered separately for the reason that the lower limit of gravity stated in the above table, viz., 25 degrees Baume, eliminates this entire group from consideration—which is not the intention of this article.

As a guide for the selection of suitable oil, the following table is given:

Table No. 3—Physical Tests of Asphaltic Base Oils.

	Minimum	Average	Maximum
Gravity, Baume....	20- 22° F.	19.8- 21° F.	19.5- 20° F.
Flash Point Open Cup	305-325° F.	315-335° F.	330-375° F.
Fire	360-380° F.	370-400° F.	385-440° F.
Viscosity (Saybolt) at 100° F...........	175-225 sec.	275-325 sec.	475-750 sec.
Color	Pale Yellow	Pale Yellow	Pale Yellow
Congealing Point (pour test)	0° F.	—0°	—0° F.

For general all around use, it is conceded that the recommendations given in Tables No. 2 and No. 3 above cover the situation as well as possible, special cases, of course, requiring investigation and special consideration before making recommendations.

Proper Quantity of Lubricating Oils.

The quantity of lubricating oil to feed to the air cylinders of compressors, cannot be stated in exact terms due to the varying viscosity of different oils, the heat of compression and the size of cylinder. It may be stated in general, however, that after the cylinders have acquired smooth and polished surfaces, the quantity should be reduced to the lowest limit to avoid the possibility of the accumulation of carbon and sooty deposits within the system due to excessive use.

The following basis of quantity given in Table No. 4 is recommended, subject to above modifications for these cylinders or equivalent sizes, operating under normal conditions.

Table No. 4—Quantity of Air Cylinder Lubricant Required per 10 Hour Day.

Diameter of Cylinder Inches	Size of Cylinder Inches	Displacement per Minute Cubic Feet	Piston Speed Feet Per Minute	Sq. Ft. of Cylinder Wall Swept by Piston	Drops Oil per Minute	Drops Oil per 10 Hrs.	Sq. Ft. Oiled per Drop	Number Pints Oil Required per 10 Hrs.
8	8 x 8	120	344	718	1	600	718	.0375
12	12 x 12	320	408	1230	2	1200	613	.0750
18	18 x 18	880	496	2340	4	2400	585	.1500
24	24 x 24	1730	550	3450	6	3600	575	.2250
30	30 x 30	2940	600	4700	8	4800	590	.3000
36	36 x 36	4550	644	6070	10	6000	607	.3750
42	42 x 42	6700	696	7600	12	7200	633	.4500

*Figures of last column are based upon estimated 16,000 drops per pint of oil at 75° F.

It will, of course, be carefully noted and clearly understood that the results in the last column of Table No. 4 are based upon the assumption that under average conditions of temperature and usual range of oil viscosities, a pint of oil will contain an average of about 16,000 drops. It is of course understood that these figures are offered merely as an approximate guide and that every individual must exercise his own judgment in modifying them wherever his own particular set of working conditions is unusual.

A leading authority on compressor engineering contributes the following: "The best way to determine the proper amount of lubrication is to take out the valves from time to time and examine the cylinder. All parts should feel that there is oil thereon. If they feel dry, the lubricators should be adjusted to feed a little more oil, whereas if oil lies in the cylinder and its parts show excessive oil thereon, the quantity fed by the lubricators should be reduced. By thus examining the machine a few times, the proper amount of oil can be determined to suit the characteristics of the particular lubricant used and the conditions under which the machine operates." This is a better way to finally determine the quantity of oil required than by adopting without this experimenting any tabulated number of drops.

Periodical Cleansing of System.

The best of lubricating oils will cause the deposit of enough carbon in the compressor system to necessitate the periodical cleansing of it.

For the removal of carbon, the machine operator should confine his efforts to the use of soapsuds. A good cleansing solution is made of one part soft soap to 15 parts water. These suds should take the place of oil for a few hours, and be fed into the air cylinders about once a week, either by means of a hand pump or through the regular lubricator at a rate about 10 times as rapidly as that of the oil. The cleanliness of the air valves when inspected, as they should be periodically, will indicate whether greater or lesser applications of the soapsuds should be made. After using soapsuds, open the drain cock of the air receiver, and of the inter-cooler in the case of compound machines, to draw off any accumulated liquid. Oil should be used again for a half hour before shutting down the machine in order to prevent rusting the cylinder and its fittings. Never use kerosene, gasoline or lighter oils in an air cylinder for any purpose whatever, because of their volatile nature under heated conditions.

Cleaning Air Receiver and Piping.

It often happens that oil, carbon and other foreign matters are deposited in the air discharge lines and air receiver. A practical method of cleaning these is shown in cut attached, where a receptacle made of 6-inch pipe is shown set on top of the discharge pipe. The cut shows plainly the construction and what the different parts represent. If a mixture of one pound of Red Seal lye and 18 pounds of water is passed into the discharge line at the rate of 60 or 70 drops per minute, while the compressor is running, this will eat out all the accumulation on the surface of the pipe and in the receiver, and if the blow-off valve on receiver is open, all of this foreign matter will be discharged therefrom. This cleaning solution can be used every month or two or depending on how much accumulation there may be in the receiver.

Steam Cylinder Lubrication.

The proper quantity of oil to be fed to steam cylinder is much greater than to air cylinders due to the constant washing away of the oil by the steam. Approximately four times as much oil will be needed in the steam cylinders as in those for air, subject, of course, to variable local conditions.

Depending on its viscosity, a pint of steam cylinder oil will furnish from 5,000 to 8,000 drops, and taking an average of about 6,500 drops, and four times as much oil as air cylinders of same size, and working

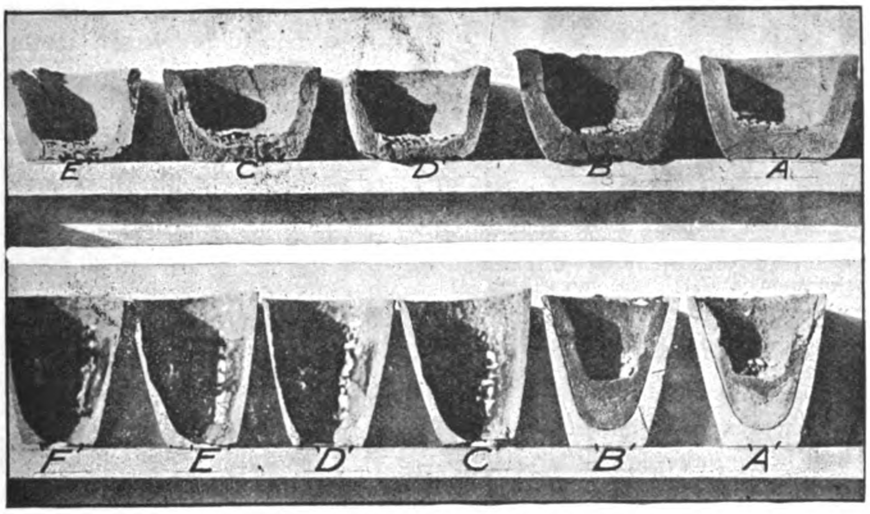
(Continued on page 242)

Basic Refractories for Open Hearths

Preparation and Use—American Magnesite Deposits—Dolomitic Refractories—Analysis of Basic Materials as Received—Analysis Calculated to Zero Ignition Loss and Percentage Loss on Ignition.

By J. SPOTTS McDOWELL and RAYMOND M. HOWE.

Magnesite is an important refractory in open hearth, heating and electric furnaces for steel making, and in many of those employed in the metallurgy of copper and lead. It is sold in the form of brick, finely ground "furnace magnesite" for bricklaying, and dead-burned grains for making and repairing furnace bottoms. The latter are a mixture of granules varying in size from pieces of about ⅝ in. diameter to fine but sandy particles. Dead-burned magnesite results from calcining the crude or lightly burned mineral at a temperature that will not merely drive off practically all the Co_2, but will also cause sintering of the particles. During this process the pieces shrink considerably and become hard, dense, and inert to atmospheric moisture and Co_2; underburned material, on the other hand, will hydrate on exposure to the air. A small percentage of ferric oxide, from 4.5 to 8 per cent in the dead-burned grains, is considered necessary for the production of a satisfactory sinter.



Magnesia crucibles showing slagging action.

Dolomite is prepared for use in the granular condition calcined or "double-burned" and is the principal ingredient of several materials sold under various trade names for refractory purposes. Dolomite refractories are almost wholly confined to the open hearth and electric furnaces, where they are used for fettling and as substitutes for magnesite.

The hearth of the furnace is usually built up of magnesite brick and dead-burned grain magnesite so laid that the brick base is protected by a working bottom of the granular material. The latter is sintered into place in layers ½ to 1 inch thick to a total depth of 12 to 18 inches at the center of the furnace. After each heat, burned dolomite is thrown against the banks as high as it will stick, and all holes in the bottom are filled. For temporary patching dolomite is generally used as it sets more quickly than magnesite and its first cost is less.

Prior to 1914 the world's supply of refractory magnesite came almost wholly from the crystalline deposits of Austria-Hungary. Its superiority lay in its high refractoriness and long range of vitrification, which enable it to frit together at high temperatures without fusion or excessive softening. These properties are imparted by a fairly high content of iron oxide, together with an extremely low percentage of harmful impurities. The dead-burned Austrian magnesite formerly sold in the United States had the following range of analysis: MgO 83.7 to 87.3 per cent; CaO 1.9 to 3.9 per cent; SiO_2 1.1 to 4.1 per cent; Fe_2O_3 and Al_2O_3 4.7 to 8.6 per cent. Since the cessation of shipping from Austria, the deposits of this country have been developed to such an extent that an adequate supply is available, and ample reserves are blocked out to last many years. At the beginning of the war the refractory manufactures were crippled by a lack of calcining facilities, and the low iron content of the available magnesite caused additional difficulties. In order to confer the proper bonding and sintering properties, it became necessary to add iron oxide and to incorporate it thoroughly by bruning it at an extremely high temperature. Magnesite thus treated, if sufficiently low in harmful impurities is a high grade refractory, and has given extremely satisfactory service.

American Magnesite Deposits.

The magnesite of the Grenville district, Canada, is finely crystalline and high in lime due to dolomitic inclusions. It is being employed for the production of dead-burned grain magnesite by sintering with iron oxide in rotary kilns, and it has been stated that when so treated it has given satisfactory service in furnace bottoms. However, the leading refractory manufac-

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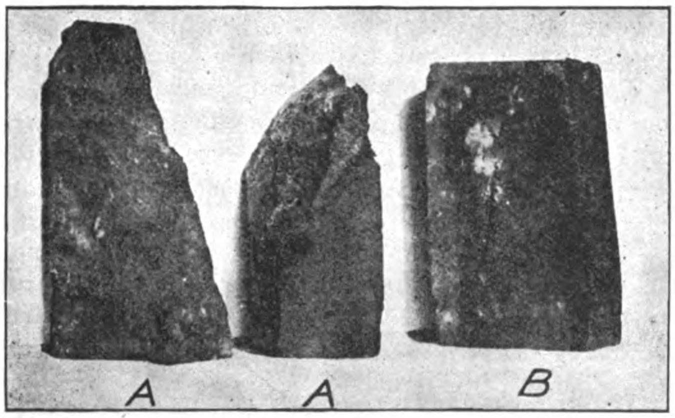
Abstract of paper read before A. I. M. E. meeting. Mr. McDowell is connected with the Research Department of the Harbison-Walker Refractories Company. Mr. Howe, Fellow, Mellon Institute.

turers prefer purer material, and endeavor to maintain the CaO content below 4 per cent in the dead-burned grains.

Much magnesite from California has been used since the beginning of the war, but the California production has recently fallen off, due to the competition of the larger and less expensively operated deposits of Washington. The latter have become a most important factor in the market since their discovery in 1916 and produced over 105,000 tons in 1917. The mineral is finely to coarsely crystalline and shows many variations in color. Mining is done by both open-quarry and underground methods. It is reported that diamond drilling at one quarry has proved the existence of more than 1,000,000 tons, and that on more than one of the properties an estimate of 1,000,000 tons within 200 feet of the surface is reasonable. Calcination is now being done near the quarries, and dead-burned magnesite for refractory use to which iron oxide is added during manufacture is being produced in rotary kilns. The material as marketed by one producer has the following average analysis: MgO, 82.5 per cent; CaO, 3.4 per cent; SiO_2, 6.5 per cent; Fe_2O_3, 7.25 per cent; loss on ignition, 0.5 per cent.



A. Typical failure of Brick A in load test. B. Failure of brick B in load test. Original dimensions 8.75 in. by 4.13 in. by 2.53 in.; final dimensions, 7.66 in. by 4.31 in. by 2.72 in.

Dolomitic Refractories.

For many years prior to the war few basic bottoms in America had been built of dolomite, which was little used except for temporary patching and the fettling between heats. Since 1914, however, calcined dolomite and specially prepared dolomitic materials have been common substitutes for magnesite, being placed in the furnace in the same way as the grain magnesite. Within recent months, however, the tendency on the part of steel-makers has been to return to the use of high grade magnesite for all original installations and major repairs.

In the calcination of dolomite either vertical or rotary kilns may be used. In the latter case the rock is usually crushed to pass approximately a ⅝-inch screen, the fine powder screened out and the granite burned. The rock is frequently "double-burned" by being heated in one kiln merely high enough to drive off most of the CO_2, and further shrunk in a second at a higher temperature.

Burned dolomite as ordinarily prepared air-slakes readily on account of the high percentage of lime. For that reason it cannot be kept in stock for any length of time without deterioration and should be made just before use. Since dolomite does not set as solidly as magnesite, patches are more apt to become detached and float in the bath.

Within the last few years numerous investigations have been undertaken in the attempt to overcome the marked slaking properties and other defects of calcined dolomite. As a result several articles consisting of specially prepared dolomite have been placed on the market under various trade names, some of which are superior to ordinary calcined dolomite, being more resistant to atmospheric slaking and giving better service in the furnace. In most of these preparations the granules are coated or impregnated with pulverized basic slag, iron ore or similar material by burning at a high temperature in a rotary kiln. In other cases the slaking properties are diminished by using an impure dolomite, preferably one high in iron. The analysis considered most desirable may be obtained by mixing raw rock of different compositions.

Laboratory Test.

The properties of the basic refractories which evidently affect their value for furnace use are:

1. Resistance to slaking.
2. Resistance to erosion or scouring action of the bath.
3. Resistance to chemical action of impurities in the bath.

A brief series of tests was run by Mr. Howe upon six commercial basic refractory materials, in which tests the relative resistance of the materials to slaking and corrosion under certain arbitrarily fixed conditions was considered.

Analysis of Basic Materials as Received.

	A	B	C	D	E	F
MgO	81.60	66.40	32.10	34.73	34.50	34.85
CaO	3.12	18.94	47.92	48.70	49.84	51.00
SiO_2	7.36	4.56	11.46	9.84	6.68	2.16
Al_2O_3........ and Fe_2O_3........	7.14	9.96	8.32	6.40	5.58	2.00
Moisture and Ignition loss	0.43	0.33	0.47	1.00	3.70	9.90

A—Dead burned Washington magnesite.
B—Dead burned Canadian magnesite.
C—A preparation supposedly made by coating dolomite granules at a high temperature with open-hearth slag.
D—A product similar to C in which the dolomite granules are reported to be coated with iron ore instead of slag.
E—A calcined impure dolomite.
F—A calcined pure dolomite.

Slaking Tests.

The materials were moistened from time to time with water, samples were taken at intervals of five days, and the ignition loss determined. The results are given below.

Analysis, Calculated to Zero Ignition Loss and Percentage Loss on Ignition at Regular Intervals.

	A	B	C	D	E	F
CaO	3.16	18.96	48.15	49.19	51.64	56.61
MgO	81.72	66.66	32.26	35.18	35.75	38.69
SiO_2......... Al_2O_3 .... Fe_2O_3........	14.70	14.54	19.88	16.40	12.69	4.62
Loss at beginning of test	0.02	0.20	0.08	0.95	1.55*	1.29*
Loss after five days	0.48	0.69	1.20	5.67	12.81	16.43
Loss after 10 days	0.95	1.52	1.62	8.35	15.80	21.51
Loss after 15 days	1.24	1.94	2.39	10.10	17.09	
Loss after 20 days	1.36	1.92	3.01	10.92		
Loss after 25 days	2.09	2.65	6.30	12.00		

A study of the figures given indicates that the lime content should preferably be low and that iron oxide, alumina and silica within limits dependent on the character of the dolomite and its treatment are necessary in dolomitic refractories if the slaking is to be kept low enough to permit storage. The low slaking tendency of C apparently proves that the granules were well protected by the slag coating. It is somewhat higher in impurities than D, a treated dolomite which slaked badly.

Crucible Tests.

The open hearth bottom is necessarily exposed, at least locally, to the corrosive action of phosphorus and silicon in the melt until they are removed. Tests were, therefore, conducted for the purpose of studying the action of these impurities upon the six basic materials. Small crucibles were made of the different products, heated to 1,350 degrees C., corrosive mixtures introduced and allowed to react for equal lengths of time. The crucibles were then cooled and the melted portion analyzed for silica, lime and magnesia in the first series, lime and magnesia in the second series. Since these oxides could come only from the crucible their presence in the melt proved chemical action. In the first series the melt consisted of one part ferro-phosphide and two parts ferric-oxide and contained 6.1 per cent P. In the second series the melt contained 0.65 per cent P, 5.20 Si, 2.60 Mn, balance Fe, with somewhat more than enough Fe_2O_3 to oxidize the impurities. In each case the per centage of impurities was made much higher than that of an open hearth furnace melt, in order that the corrosive action might be sufficiently intense to give measureable results in one to two hours in the laboratory.

The superior resistance of A, the magnesite low in lime, to the corrosive action of both melts is clearly shown in the above figures. With the exception of material E the results of the two series are fairly consistent and place the various products in the same order of resistance to corrosion. The impure dolomite E was comparatively little affected by the high P melt, but was badly corroded by the melt high in Si. The specially treated dolomites C and D withstood the action of the high Si melt far better than did the untreated dolomite E.

Average Analysis of Slags From Crucible Test.

Material	Series I—High P Melt				Series II—High Si Melt		
	SiO_2	CaO	MgO	Total	CaO	MgO	Total
A	0.10	0.10	0.83	1.03	Tr.	0.81	0.81
B	0.32	0.16	1.44	1.92	0.33	3.58	3.91
C	1.44	1.11	1.14	3.69	1.97	2.33	4.30
D	5.31	3.02	4.16	12.49	4.73	3.59	8.32
E	1.17	0.98	1.11	3.26	23.40	13.60	37.00
F	0.92†	3.58†	3.30†	7.80†			

Load Test.

In order to study the rigidity of magnesites A and B at high temperatures, bricks made from each by the usual brick making methods, were heated under a load of 25 pounds per square inch, applied on the end of the brick with a temperature increase of 250 degrees C. per hour until failure resulted. Brick A failed by shearing at 1,555 degrees C., brick B softened and settled at high temperatures; at 1,450 degrees C. it had shortened 12.5 per cent of its original length. If, as may safely be assumed, the boiling of the bath has a greater tendency to scour out holes in a bottom which is soft than in one which is more rigid, it is to be expected from the above test that of the two magnesite, material A should show the greater resistance to the erosion of boiling metal.

Summary.

1. Comparison of Low-lime and High-lime Magnesite—The magnesite that was the lower in lime showed less tendency to slake and higher refractoriness, as well as greater resistance to attack by firebrick and silica brick, and to the action of the corrosive mixture.

2. Comparison of Dolomitic Materials—The materials highest in impurities and lowest in lime were most resistant to slaking. With one specially prepared dolomite C in which the granules had been coated with basic open-hearth slag, the inherent tendency of dolomite to slake had been overcome to a great extent. Another special preparation of similar character D showed practically the same degree of slaking as the untreated dolomites. The specially treated dolomite C withstood the action of the corrosive mixture not quite as well as an untreated dolomite high in impurities, and much better than the second special preparation D. Except material D, the purest dolomite showed the poorest resistance to corrosion, although this may perhaps be explained by the high ignition loss of the material as received and used.

3. Comparison of Magnesite and Dolomite—The magnesites are more resistant than the dolomites or dolomitic preparations to slaking, also to the action of the corrosive mixture and that of fireclay and silica.

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* E and F had been recalcined at the laboratory before the test.

†Approximate.

Practical Operation of Gas Producers

Starting a New Producer—Methods of Measuring the Fire. Generation of Hot and Cold Gas—Cooling Fires—Steam Requirements—Cooling Water.

By J. S. M'CLIMON,
Assistant Engineer Gas Producer Department Wellman Seaver-Morgan Company.

Most articles on gas producer operation consist of a long discussion of theoretical conditions or chemical reactions. It is the aim of this article to reduce the causes and effects of these things to a rule of thumb method which will be of assistance to the operator or superintendent and may be applied to every day operating conditions met with in producer practice.

Starting the Producer.

A new producer, before being started, should be dried out several days with small fires. This is a precaution which, if properly carried out, will add considerably to the life of the lining. After the producer has been thoroughly dried, all large pieces of wood likely to cause trouble should be removed and the producer filled with ashes to a depth of at least 12 inches over the top of the blower. It is best that a few large clinkers be placed around the openings of the blower to keep them from becoming clogged with fine ashes. These ashes are necessary to protect the metal parts of the producer. They also act as a diffusing medium to distribute the blast over the entire fuel bed thus insuring even combustion.

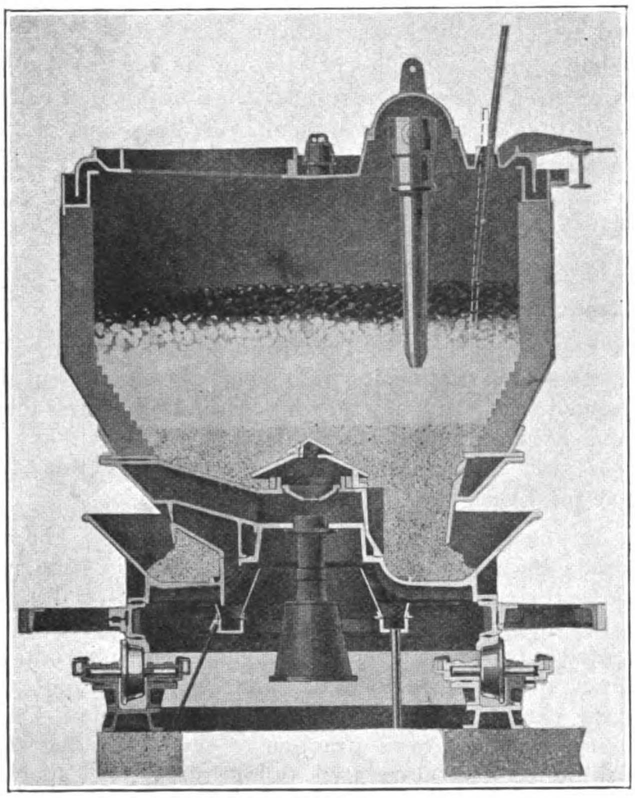

Fig. 1—Sectional view of producer showing the three zones.

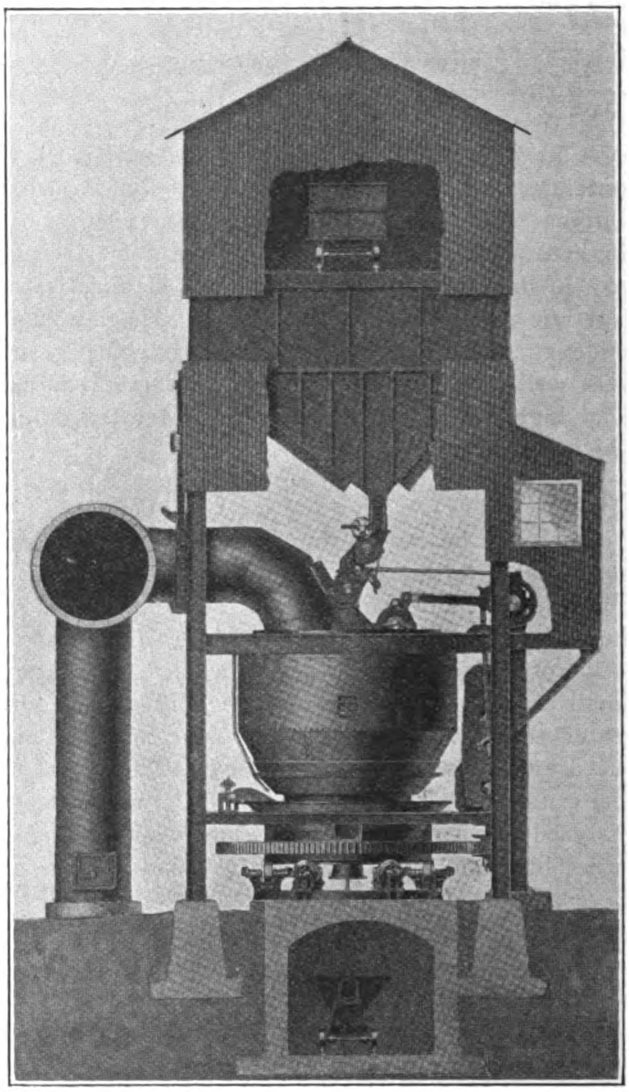

Fig. 2—Section through producer house.

To start the producer, it is necessary only to level off the ashes, throw in several armfuls of small dry wood, saturate with kerosene, and light with a piece of waste. After the wood has burned for a few moments, turn on about 10 pounds of blast and blow until the wood is well ignited. A small amount of coal can then be dumped and the fires be built up gradually. Care should be taken that the coal is not fed too fast. Allow a good bed of coke to be formed before any attempt is made toward crowding the operation of the producer. One should remember that it takes several hours to get a producer fire built up properly to the point where it is making good gas.

No special attempt need be made at this point to get the fire distributed over the entire fuel bed. It will spread of itself later and it is usually better to have a good fire at one point than several small ones scattered over a larger area.

In case it is necessary to stop the producer at any time, the blast should be immediately turned off and never exceed 10 pounds during this idle period.

Three Zones.

The various zones of the producer are shown in the cut on the previous page. It can be seen that there are three—the ash, the incandescent or the fire zone, and the green coal zone the last consisting of coal which has not received a sufficient amount of air to become incandescent. This is also termed the distillation zone. The existence of these three zones is a point often overlooked in the operation of the producer.

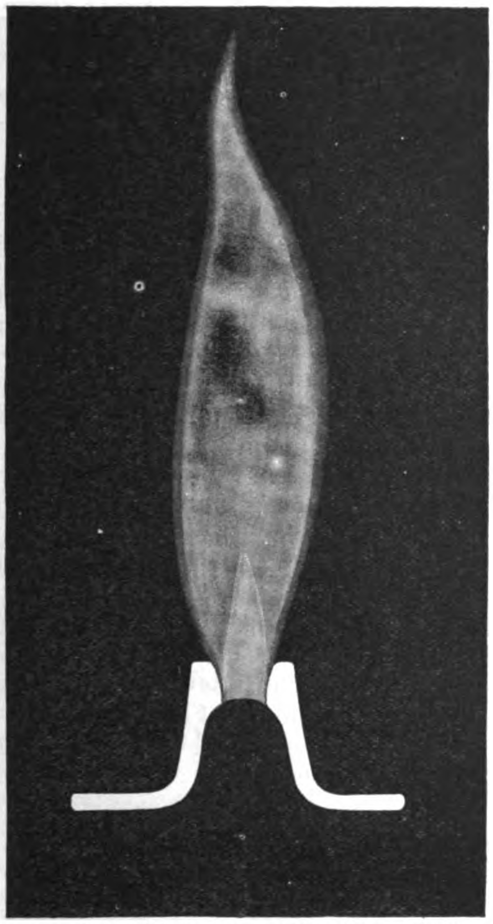

Fig. 3—Appearance of hot gas temperature about 1,300° F.

Measuring Fires.

The usual method of measuring the fires is for the foreman to take a rod about five feet long which he inserts in one of the poke holes in the producer top until he establishes the height of the fuel bed. This method is totally inadequate because no attention is given to the depth of the fire zone, the most important point of all in the operation of a gas producer. If the ash zone is allowed to exceed a reasonable limit, say 15 inches, the fire zone is considerably reduced and it is impossible to carry the proper depth of fire if the ashes are not kept within a reasonable limit.

This tendency of the ashes to crowd out the fire zone make it possible for the top of the fuel to be at the proper height and yet the fire may be so thin that the gas will be of exceedingly poor quality.

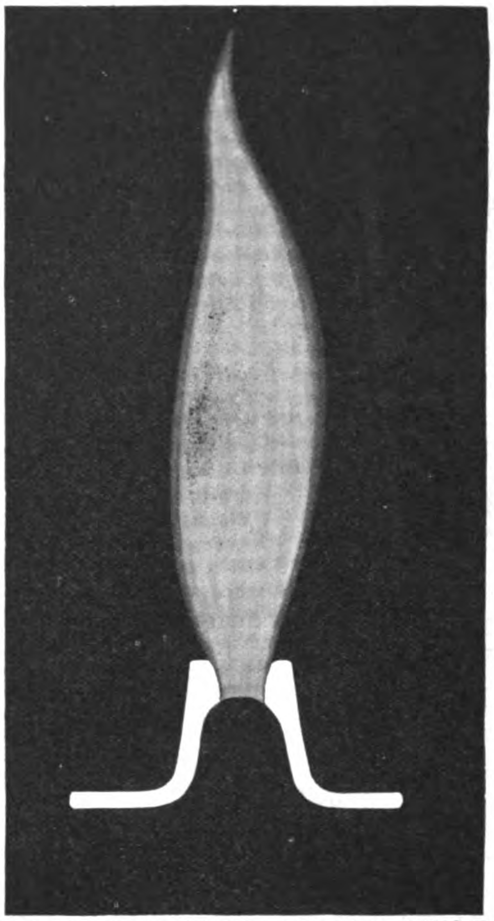

Fig. 4—Appearance of cold gas temperature 1,000° F. or less.

The only way the fires can be properly measured is to force the rod completely through the fire and allow it to remain long enough to become red hot. After the rod has been withdrawn, it is easy to see the part which has been in contact with the hottest portion of the fire and the part which has been protected by the ashes. Knowing the distance to the blower or the metal parts of the producer, it is a simple matter to tell exactly the depth of the various zones.

A very convenient rod for this work consists of a ¾ inch gas pipe marked into two foot sections by ¼ inch rivets running through the pipe. Any other method of marking may be used which will not be destroyed by the action of the fire or interfere with the passage of the pipe through the fuel bed. A mark is also placed at the height equal to the distance between the blower and the producer top. This indicates the distance the rod should be forced into the producer. In using the rod, the distance to the top of the fuel bed is first determined.. (See Fig. 1.) The rod is forced through the fuel bed until the lower end is on a level with the top of the blower and allowed to remain there for two or three minutes. This is usually all the time necessary for the rod to remain in the fire. On being withdrawn, it will be noted that there are two parts which show up distinctly—one a smoky black extending for several feet, and the other a very hot portion usually from 12 to 14 inches in length. This latter indicates the incandescent zone. Below the lower point of this zone and the end of the rod, there is a portion not affected by the heat and it should not be very hot. This is the ash zone and should never be less than 6 inches and seldom, if ever, exceed 15 inches.

Between the highest point of the hot portion of this rod and the distance determined to the top of the fuel, there will be a space of from 6 to 12 inches. This is the green coal zone. If the coal is of a tarry nature, it is possible that this zone will stand out distinctly by a tarry deposit upon the rod which can be readily distinguished from the sooty deposit above this section. The sooty portion of the rod represents the part in contact with the gas.

It is not intended that this method of measuring the fires should be employed more than two or three times per day, depending upon the number of times the fires are cleaned, but this is the only way the ash zone and the fire zone can be measured and the amount of ashes that it will be necessary to remove be determined.

If the fires are measured just before the change of turns twice a day, it eliminates all chance for the men to excuse their own indifference by blaming the other shift for trouble which might be of their own making.

Hot or Cold Gas.

The green coal zone mentioned in previous paragraphs may vary with requirements. If it is intended to generate a hot gas, that is, gas leaving the producer at a temperature of about 1,200 degrees F., the coal zone should not be allowed to exceed 6 to 8 inches. The gas showing when the poke hole cover is removed will be a brownish-black and a small pilot flame or color cone of about 3 inches in length, will appear in the center of the escaping gas. If, however, it is desired to generate what is termed a cold gas, a deeper layer of coal must be carried over the incandescent fuel. This may be anywhere from 8 to 15 inches depending more especially upon the nature of the fuel. Under these conditions, the gas appearing when the poke hole cover is removed will be a bluish-white and the temperature when leaving the producer may be as low as 700 degrees F. This is by far the richest and best gas for most purposes. The hot gas usually carries a Btu value per cubic foot of about 150, while the cold gas may have a value of 170 to 180 Btu per cubic foot.

Some operators insist that cold gas will not operate efficiently in open hearth furnaces or other places where it is desired to carry a melting temperature. This is a matter open to some discussion. We know of several open hearth plants in very successful operation using cold gas by preference.

Points of Attention.

Some coals have a tendency to become soft and pasty under the action of the heat in the producer. This restricts the passage of the gas and owing to the fact that the pressure accumulates under the steady blast, the gases will seek channels to break through the resistance of the fuel bed. These points then become excessively hot, melting the ashes and other foreign particles in the coal which form the basis of clinkers.

If the coal in use is of this nature, care should be taken to see that these channels do not form. This can be done by close attention to the stirring and the regulation of the blast, or it may be necessary to change the mixture of the blast increasing the proportion of steam to the amount of air blown. This will lower the temperature of the fire and thus considerably decrease the tendency for the fires to clinker. It should be remembered that the change should not be carried to the point where the CO_2 content in the gas becomes excessive or the fires are so cooled that the carbon in the coal is not properly gasified. Either of these items determined a certain amount of loss, but the situation should be considered as a whole and decision made as to whether the stoppage due to clinkering and the extra labor attendant to the same are not more than an offset for the few percentages of the CO_2 or a slightly increased amount of carbon in the ashes.

Cleaning the Fires.

It is the usual custom to clean the fires about two or three times a day, depending upon the amount of coal burned and the percentage of the ash in the coal.

It is not necessary that the operation of the producer be discontinued during the cleaning period. The fire should never be lowered more than 8 or 10 inches during one cleaning period, and the coal should be dumped as during the regular period, although usually in smaller amounts. It is better to lower the pressure on the blowers 10 or 15 pounds during this period. If two or more producers are arranged to operate on the same line the other products should be blown slightly harder during this interval and if this operation is properly carried out, the entire battery of producers may be cleaned without the slightest effect noticed in the operation of the furnaces. During the cleaning period, careful attention should be given to any clinker formations that are likely to appear on the side wall. These should be broken loose and the side walls kept clean.

Feeding Coal.

The proper dumping and distribution of the coal charges have a decided bearing upon the conditions obtained in producer operation. The coal should be dumped in as small quantities as can be conveniently arranged and strict attention should be paid to the color and appearance of the gas which shows whether or not the fuel bed is of the proper thickness.

Steam Requirements.

The amount of steam required to blow the producer varies with requirements. If it is necessary to crowd the machine, more air is needed to burn the increased amount of coal and as the proportion of steam and air must be maintained, it is only necessary to increase the steam pressure until the proper amount of aid is delivered. This in no way affects the quality of the gas if the fires are kept in the proper condition. Gas of just as good quality can be made at 100 pounds pressure as at 15 pounds, only the volume will be greatly increased and it is possible for the fires to get out of order much more quickly. It is hard to set a definite limit upon the amount of steam required but as a general thing it is seldom necessary to use more than 40 pounds of steam to get the desired results.

Cooling Water.

In starting a new producer, the top plate has a tendency to run hot and will usually require about all the water that can be applied through the three connections furnished. After a few days, the top plate becomes coated with carbon and the quantity of the water can be considerably reduced. The overflow from the poker is usually sufficient for all purposes and this amounts to approximately 15 to 20 gallons per minute.

If for any cause the water pressure should be lost so that no water will flow through the poker the producer should be immediately shut down and every effort made to keep the poker cool by means of an emergency line of steam or air. Caution should be exercised in starting the water to flowing through the system because if a large amount of cold water is allowed to strike the poker there is danger of the point breaking, making its replacement necessary.

The life of a poker tip is from six months to a year, depending considerably upon the condition in which the operator had kept his fires. This tip is a separate point screwed into the main barrel of the poker while the latter is heated to a cherry red color. This method of applying new tips should be used to prevent their working loose under the action of the fire. It is good policy to have a spare poker and trunnion ready for immediate use and the entire poker and trunnion changed if it is necessary to make a replacement during the operating period. This operation should not require more than 20 minutes.

Shutting Down.

In most installations, there are periods when the furnace is down for repairs. This time should be taken to clean out the producer completely. The side walls should be cleaned, the blower and blast boxes cleaned out and any mechanical part needing attention should be repaired. This procedure, if carried out, will never amount to a great deal of labor and it will be more than repaid by the increased reliability of the machine and the success attained in its use.

Combustion Considerations of Solid Fuel

Some Facts Concerning Air Influence During Combustion. Smoke Elimination by Correctly-Designed Boilers and Settings and by Proper Operation—Combustion Space and Flame Length.

By A. D. WILLIAMS.

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Obvious discrepancies may be noted in various methods of burning solid fuel, particularly coal. In the gas producer a fairly thick fuel bed is used supported on a bed of ashes. Air under pressure is blown upward, partial combustion occurs and the gases taken off at the top of the producer contain an extremely large proportion of the heat units which may be obtained from the fuel. The method of increasing the gas output is to increase the quantity of air forced through the fuel bed. Partial combustion in this manner has been known for many years. A large number of gas producers of many makes have been placed in operation. Much study has been devoted to the operation of these gas producers with various kinds of fuels. They all give forth a combustible gas. As a technical problem the reactions which occur in the gas producer are simple. Reduced to its simplest form the gas producer consists of a bell shaped enclosure which is tight enough to resist low gas pressures. The upper part of this enclosure is provided with an opening through which the gas may pass to the gas main, an opening through which additional fuel may be added, and several small openings or poke holes. The bottom of the bell is closed by a water seal through which the ash is withdrawn and the air for combustion introduced. A steam jet blower being generally used as the decomposition of the steam keeps the temperature low enough to reduce the clinkering. At the same time the small amount of water gas produced is useful.

There is neither wizardry or witchcraft in the combustion of coal. The fuel does not know or care on what grate it is placed. Combustion today follows exactly and without deviation the same natural laws that were established at the beginning of time. Solid fuel has always burned in the fuel bed to a combustible gas. This gas has then burned above or beyond the fuel bed, requiring an additional air supply.

In burning solid fuel on grates or stokers the gas producer action of the fuel bed has been ignored. Consider a boiler setting. The only way in which it differs from a gas producer lies in the large volume of the space above or beyond the fuel bed and the placing in this space of a large area of water cooled surface. When the first boilers were built and set steam pressures were low, only a small amount of power was developed; the setting was crude and leaky. When it was desired to burn more fuel on a grate the draft was increased by means of a chimney. If that proved in-

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sufficient the example afforded by the smith's open forge fire was followed and air was blown in below the grate. As long as the fire doors and setting leaked sufficient air to support a flame all went well and no one worried as long as the outfit supplied sufficient steam to keep the engine going. This is the condition that exists in many boiler plants today. Not only in boiler plants but in many metallurgical furnaces and in practically all domestic uses of solid fuel.

It is known that combustion in the fuel bed is only partial and it is important to establish the sources of the air required to complete the combustion of the poor gas produced. When coal is placed in a firebox it must be heated to its ignition temperature, before it can burn. All moisture and volatile matter is driven out of the fuel. The caking coals become plastic and form coke. In hand firing this must be broken up by slicing and the secondary air supply enters through the firing doors and holes in the fire. Whenever the firing doors are opened there is a big inrush of air. Osborn Monnet's work states that from 10 to 20 per cent of the total draft at the flue connection is available over the grate. If the draft over the grate is 0.10 in. of water it is sufficient to impress a velocity of 20 feet per second upon the entering air. With 0.50 in. of water this velocity will increase to 44 feet per second. Even with a liberal allowance for entry head, etc., it may be seen that an open door will supply a very large quantity of air.

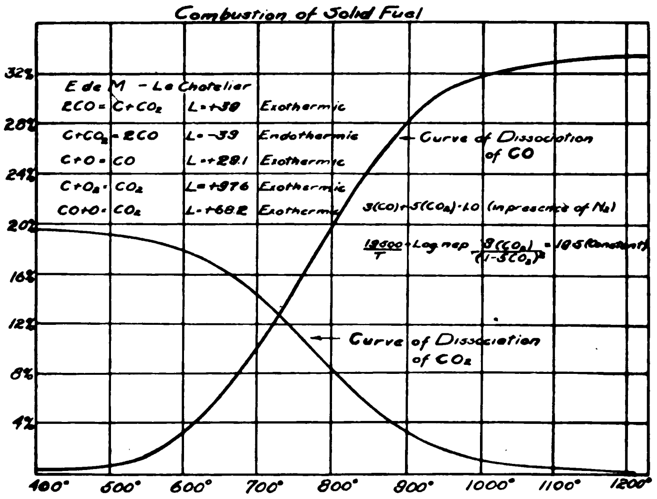


Fig. 1—Equilibrium curves of CO and CO_2 in the presence of nitrogen.

A very interesting illustration of how the air may enter through holes in the fires occurs with the underfeed stokers which employ a pressure air supply. The pressure of the air below the grate is regulated to suit the rate at which the fuel is fed into the fire. Close observation of the fuel bed will show that it suddenly cracks and shows a white hot streak. This streak occurs where the cake of plastic coal breaks as additional coal is fed. As soon as such a break in the cake occurs a stream of air at a very high velocity is forced through the breach. When the boiler is being operated around 300 per cent of rating the pressure below the grate is sufficient to impress a velocity of 180 to 200 feet per second on the air. Under these conditions it does not take a very large hole to admit a big volume of air. This air blast heats the coal on each side of the crack to incandescence. These cracks open and close periodically following the action of the feeding rams. When these cracks open the intense combustion started on their sides tends to widen them burning away the combustible and slagging off the cinder or ash.

The air entering under the cake also has a tendency to flow to the edges of the cake, more particularly the edge nearest the dump plate. Here it passes through the ashes into the firebox.

The portion of the air that passes up through the fuel bed amounts to about one-half the theoretical air supply or less. This air is preheated in passing through the layer of ashes. It then enters the preliminary combustion zone and combines with carbon forming CO_2. Rising above this zone the CO_2 dissociates forming 2CO by taking up carbon from the preheated descending fuel. The gases leaving the fuel bed contain from 10 to 30 per cent of combustible.

Combustion of Solid Fuel.

Reaction	Heat per Gramme Molecule Released Calories	Absorbed Calories
$C + O_2 = CO_2$	97.6	...
$C + O = CO$	29.4	...
$CO + O = CO_2$	68.2	...
$CO_2 + C = 2CO$	...	38.8
$2CO = CO_2 + C$	38.8	...
$2CO + O_2 = 2CO_2$		136.4
$2CO = CO_2 + C$		38.8
Heat lost (By formation of soot. Dissociation of CO.)		97.6

The column of descending fuel is heated by the ascending gases. It first loses its moisture, then a portion of the volatile matter, some of them going with the water. This volatile matter is mainly hydrocarbon compounds which distill off according to their vaporizing temperature. These compounds break up into floculent carbon and hydrogen almost instantaneously. This form of carbon is light but it is difficult to ignite. Unless this carbon is heated to its ignition point before reaching a water cooled surface it passes off in the form of smoke or is deposited as soot.

The ignited fuel gives up a considerable portion of its carbon to the ascending current of carbon dioxide. Fig. 1 shows the equilibrium curves of CO and CO_2 in the presence of nitrogen. This curve was plotted from data given in Bulletin No. of 7 the Bureau of Mines. In the fuel bed the formation of CO from C and CO_2 is an endothermic action absorbing 39 calories per gramme molecule of CO_2 dissociated, or for each two molecules of CO formed. The table gives the thermal value of these reactions.

Above the fuel bed the combustion of gaseous fuel is simply a matter of mixing and diffusion at a temperature above the ignition point of the gases involved. Combustion may be quenched by the cooling effect of the tubes and secondary combustion may occur when the gases emerge from the water cooled zone.

It is not known how much of the soot is due to the breaking up of the hydrocarbons or to the dissociation of CO or how much soot passes off in the form of smoke. In some cases as much as 200 pounds of soot has been collected in a boiler setting per ton of coal burned. This being in addition to the loss in the smoke. From 20 to 60 pounds of soot per ton of coal is not unusual. Boiler soot is not entirely carbon as it is mixed with coke, coal dust and ash. Carbon has a heat value of 8,133 calories per kilogramme (14,580 Btu per pound). As from 1 to 10 per cent of the fuel forms soot and flue dirt, it is easy to approximate the loss from this cause. This loss is largely preventable. The only reason that it occurs lies in the setting of boilers in a manner that promotes the formation of soot and dirt. The method of baffling is likewise well calculated to form gas eddies and pockets in which a portion of the dust and soot will be deposited.

Entirely aside from its heat loss value, which is small, smoke elimination is important. In large cities the smoke evil is serious and an effort is made to regulate it and prevent smoke. There are two ways of eliminating smoke.

First—Properly designed boilers and settings.

Second—So operating improperly set boilers that they do not produce smoke.

This last means trapping the soot and dust in the setting and flues. It also means investing several times as much money as is necessary or desirable in steam generating plant. That is the output from a boiler must be limited to point at which it will not produce more soot than can be trapped in its setting and flues. The second method is widely used.

The design of the correct form of furnace for any fuel is not at all difficult and does not call for any occult or esoteric knowledge. It merely involves attention to those absurdly simple elementary physical laws which govern the flow of gases. Observance of these laws brings unqualified success. The performance of the furnace can be predicted with the same degree of accuracy as the performance of a steam turbine or engine. Combustion requires a certain amount of time in order to permit the combustible and the comburent to become mixed. This time element and the amount of combustible absolutely determine the volume of the combustion space. The length of a flame may be governed in the following ways:

1. Intimately mixing the combustible and comburent by admitting them through a number of small apertures will produce a short flame.
2. Use large apertures and a long flame will be produced.
3. With both of these methods increased velocity will lengthen the flame.

Gases tend to stratify according to their temperature. When the combustible and the comburent are shot into a straight horizontal flue or tunnel, the travel distance required for complete combustion will depend largely upon their velocity and whether they fill the flue or not. In this case the hottest gases tend to flow along the roof and the coolest near the bottom, this last being the air. Mixing by convection and diffusion is necessary to bring them together.

This tunnel condition is the one that exists in many metallurgical furnaces.

International Finance and Steel Exports

Reasons for European Dominance in Steel Export Previous to War—Methods of Developing Foreign Trade—Necessity of Steel Manufacturer to Aid Consumer in Finding Market.

By L. W. ALWYN-SCHMIDT.

By lowering the productive effectiveness of the European steel industry the war has caused a deflection in the direction of the demand for steel which now may flow at a marked increase to the American steel mills. This development cannot astonish very much; it is, in fact nothing else but the natural outcome of the evolution of the American steel industry during the last decade. It was certainly an anomaly that the European steel producing countries with their production much below that of the United States steel industry should nevertheless have been able to outmatch the American industry both in the value and the quantity of their steel exports. But while economically an anomaly, the position gained by the European steel industry was not undeserved. It was the result of much work spent in the development of the world's markets and of a liberal investment policy followed by European financiers in support of the foreign business of their respective industries. The effect can easily be traced all over the world. It is a case of trade following the capital. It is the secret of the enormous hold gained by the English industry upon the world's markets and the rapid growth of the export trade of the German steel industry during the 25 years preceding the European war. There has taken place during the last 40 years a steady infiltration of European capital into Asia, South America, Australia, South America. The principal railroads of South America have been built with British capital. France has supplied the sinews of developing transportation in Russia, Germany has constructed ports, power stations and factories in many parts of the world. And in each case the financiers had stipulated that European materials, meaning English, French or German, should be used. Naturally capital could be well spent for such purposes. The investments were not always the best. Profits and interest payments often were not recoverable for many years. But in the meantime the banks and financiers were well repaid for their outlay by the orders that came to the factories of their own country. The German bank might well lend money on the doubtful security of a new power station in South America when it knew that the machinery for that station would be supplied by a German electrical company in which the German bank was a large shareholder.

Finance and industry have in this way coöperated very closely all over Europe and the large financial interests have always been able to enlist the aid of their governments in these ventures. International financing, therefore, had become a very complicated operation in which the individual moves were fully backed with all the forces of the nation. It is well known that Germany intended to go to war for the purpose of collecting the interest payments of a Venezuelan railroad enterprise where German financiers had invested capital. Also the so-called Morocco affair where Germany backed up two financiers in an ore speculation is now sufficiently known, being one of the events which led up to the present war.

While this kind of sharp financing which is willing to embroil whole nations into a war over a stock speculation cannot be condemned heavily enough, there is no denying that under present day conditions no industry can expect to do a large export trade until it receives a certain financial assistance. This has to be supplied by the financial interests of each country and must be rendered independently from the financial aid given generally to manufacturers. It has to take the form of a policy of foreign investing which has as its principal aim the development of the resources of other countries providing incidentally support to the exporting industry. The steel industry requires this form of assistance more than any other. The steel industry is placed rather unfortunately as to the distribution of its products. There is no independent market for steel. Steel is not supplied to the multitude and it reaches its real market only after having gone through many intermediate hands. The manufacturer of cutlery, of textile machines, of rifles, to take a few examples, may make a market for his products by stealthy advertising. He may increase the demand for cutlery. A well designed textile machine will find a market among textile mills, and rifles can be sold by creating an interest in shooting or marksmen clubs. But the steel manufacturer must wait the pleasure of the manufacturer consuming his product. His sales are dependent upon the success of the advertising and selling campaigns of the cutlery manufacturer or any other of his customers. The situation is not an enviable one and is keenly felt in steel circles.

To increase his sales it would be necessary for a steel manufacturer to assist in building up the market of his consumer. He would have to operate over his head, create a new market for cutlery or machinery and by doing so add to the demand for steel. This is done on behalf of the steel industry by the investor who employs his capital in the development of new markets. A railroad built in South America or China does not create a demand for steel only for the purpose of making rails and rolling stock. It helps to open also new fields of industrial and economic enterprise which in turn produce a demand for all those goods which require steel as their basic material or machinery made from steel for their manufacture. The effect of capital investment on the demand for steel can easily be seen every year in our own country. Let a new railroad tap a promising farming or mining center. In a few years the population of the district doubles. Additional tracks and railroad cars to handle the traffic are required. Hundreds of houses are built, into the making of which goes steel in many forms. There are hardware stores which did not exist before, all making for an increase in the consumption of steel. The same process is duplicated with much larger force in countries which do not have so advanced an industrial development as our own. A new railroad in South America means more to these countries than a new line in the United States. Its mere existence adds millions of dollars to the value of property which was practically useless before. Naturally these profits will not accrue to the United States steel industry alone but the country asisting financially will get the largest share. The situation is just now extremely favorable for such a development.

Before the war it was Europe which gave its financial support to the world. When South American railroad constructors, builders or governments required capital they would go to London, Paris or Berlin; and as a rule money came forward in sufficient quantities. They would then be made to undertake to take part of the payment in merchandise, in steel rails, girders, building materials, or whatever might be necessary for the execution of the project. Now Europe will not be able any more to help so readily. Its financial strength has been spent over the war and it will take many years before its financiers can resume again their free handed investment policy. America, although it has spent probably not much less than any individual European country, has accumulated large financial reserves. It has mobilized its financial resources to an extent which had not been thought possible, and its cash has become better available. The American investor has become accustomed to see matters with an international eye. Having once bought the bonds of foreign governments to the tune of more than $1,000,000,000 he will not be any more so reticent in investing his savings in foreign enterprises as he was before the war. Money, therefore, can be made available for foreign investments in practically unlimited amounts provided the investor can be offered the necessary security. He must know that he will find reliable banks to handle his foreign investments and he must know that his money is spent in profitable enterprises. Finally he must have some sort of a national guarantee. His investments should not be of a character that they may embroil the nation in an international conflict, as public opinion in this country will be strongly adverse to backing up financiers in shady enterprises. The investment should be made secure by international agreements protecting the bona fide investor.

Our steel industry is very largely interested in such a development of the national foreign investment policy. We have gained many new markets for steel and the products of the steel industry during the last four years, and we cannot very well afford to let drop too much the manufacturing activity in the steel industry. By a peculiar knack of economic interdependence the well-being of the American steel industry is closely connected with the well-being of the whole nation. A sudden breakdown in the steel production is invariably followed by a widespread economic depression all over the country. If we should be compelled now to reduce materially the output of our blast furnaces we might very well have a repetition of the great panics that have swept our countries. We are, therefore, all, not only the steel men, but every American, vitally interested in a continuation of the prosperity of the steel industry. We cannot expect that Europe will buy as much steel from our steel mills as she did during the war, but we may reasonably expect a perpetuation of the present demands from the non-European markets with a marked increase in orders from the same direction as soon as our means of delivery have been improved.

South America, the Asiatic East, Australia and many other important markets have been starved for steel and iron during the war. They have also had hardly any capital to continue their economic development work. They will now be only too ready to accept deliveries of both. South America especially will be appreciative of our help and according to the statements of our financial experts it appears that financial help will have to precede before a large demand can be expected for steel. This is a matter for our banks to consider. They are not so closely interconnected with the steel industry in this country as they have been in Germany; but the well-being of the steel industry cannot be a matter of indifference to the American banks and financiers. If they can furnish the capital for South America to continue the development work interrupted by the outbreak of the European war, the steel industry will soon notice the effect by an increase in the demand for steel manufactures. And the profit will not be the steel industries alone. The American machinery industry, the American builders, in fact the whole American nation will be a partner in this vast enterprise.

Lending money for the purpose of assisting economic growth is a friendly service much appreciated by any country. It will help a good deal to cement the friendship between North and South America and between the American nation and all the other nations of the world. We shall then have a right to claim the goodwill of these markets in the selection of the materials they require, and we no doubt shall have all the orders which can be reasonably placed in the hands of the American industry. The steel industry being a basic industry will certainly not suffer by such a course of action.

Considerations With Regard to Fuel Gas

Particular Consideration Given to Water Gas and Cleaned Producer Gas—Estimates of Cost of Water Gas Plant. Methods for Cleaning Producer Gas.

By FRED CRABTREE.

An interesting paper entitled "Some Considerations With Regard to Fuel Gas," was recently read before the Engineers Society of Western Pennsylvania, by Prof. Fred Crabtree, Professor of Metallurgy, Carnegie Institute of Technology, Pittsburgh.

The author pointed out that due to the increasing shortage of natural gas, new ideas and improvements in the utilization of fuel are constantly being developed. Natural gas being a stable, fixed gas, only slightly affected by ordinary charges in temperature, free from dust, tar, or injurious solids; of high calorfic power, permitting of the attainment of high temperatures without preheating, and of the use of small mains; free from sulphur and not actively poisonous, in addition to having low cost, is such a good fuel that considerable difficulties present themselves in an endeavor to find a substitute. For large types of furnaces such as open hearths uncleaned producer gas may be used which, although inexpensive, has limitations due to its low calorific power and large content of soot and tar.

Powdered coal also presents possibilities on larger types of furnaces. To meet the demand for a clean, stable artificial gas free from tar, soot, or any other substance that will tend to settle in the mains or clog the valves, the following gases are considered:

By-product coke-oven gas.
Bench gas (ordinary coal gas).
Cleaned producer gas.
Water-gas (blue gas), carburetted or uncarburetted.

The use of by-product coke oven gas is of course chiefly restricted to large companies which for other reasons, are justified in the high initial cost. Distilled gas (bench gas) similar to by-product coke oven gas in qualities, is prohibitive, unmixed with other gas, for manufacturing purposes, due to its cost.

"Water-gas, frequently called blue gas, has a somewhat lower heat value than by-product gas (usually about 300 to 325 Btu per cubic foot) and is stable and free from tar, soot and other deleterious solids. For certain types of furnaces it is excellently adapted; in fact, almost as satisfactory as natural gas. Its composition varies slightly, but a typical analysis is given as follows: CO, 43.5 per cent; H_2, 47.3 per cent; CH_4, 0.7 per cent; CO_2, 3.5 per cent; O_2, 0.6 per cent; N_2, 4.4 per cent.

Being composed almost entirely of CO and hydrogen, its flame has comparatively low radiating power;

hence it would not be satisfactory in open-hearth furnaces or other reverberatory furnaces depending on a flame with high radiation effect. But it is very satisfactory for furnaces depending on convection or conduction, especially those where close adjustment and regulation are desired—as, for example, furnaces of the surface combustion type, whose accuracy of control and high efficiency should lead to widely extended use. Having a comparatively high calorific intensity, or flame temperature, it can be used in many furnaces without preheating, thus saving the cost of regenerative or recuperative chambers. It can, of course, be used equally satisfactorily where milder temperatures are desired.

The fuel required—either anthracite or coke—places some limitations upon the extended use of water-gas; but one or both of these can usually be obtained at a reasonable price at most of the leading industrial centers, and Pittsburgh is pretty well favored in this respect. To get the best results with coke, a good strong coke, equivalent to that required for blast furnaces, is desired. It is not necessary that the coke be in large pieces; but owing to the evil effects of irregular distribution of the blast (channeling) a reasonable degree of uniformity in size is desirable. Experiments have been tried with a mixture of coke and bituminous coal, with the object of getting a richer gas, containing some illuminants. The idea is alluring; but, so far as could be learned, all these experiments gave unsatisfactory results and indicated that a straight coke charge is better than a mixed charge.

Water-gas has been extensively used for 30 years or more in the production of artificial illuminating gas in nearly every city of any considerable size; but for this purpose it has to be enriched, or carburetted, by means of oil, sprayed onto highly heated checker brick through which the water-gas is passing. The oil is broken up, forming fixed gases that mix with the water-gas, giving a resulting mixture that has a heat value of 600-650 Btu to the cubic foot. This is one of the richest gases obtainable, but the high price of oil ordinarily makes the increase in heating value too expensive to be justified for industrial purposes.

Costs of construction are, of course, quite variable, in accordance with business conditions; and so are operating costs. So many of the factors involved vary with each individual plant that, without some knowledge of these factors, definite figures are apt to be misleading. But to the engineer and business man they are all important; so I venture to offer some estimates made in regard to one or two separate installations that were under consideration.

For a plant to furnish the equivalent in blue gas of 22,000,000 to 24,000,000 cubic feet of natural gas per month (800,000 cubic feet per day), the installation cost early in 1917 was roughly estimated by the manufacturers of the equipment at $175,000 to $200,000, and the operating cost at 15 to 17 cents per 1,000 cubic feet—or the equivalent of 45 to 55 cents per 1,000 cubic feet of natural gas.

Quite recently there was made a very careful study of blue gas manufacture, and an estimate for a plant of about 40 times the capacity of the one above mentioned. Including some refinements or improvements in equipment and methods, the estimated installation cost over $3,000,000, and the estimated cost of the gas less than 8½ cents per 1,000 cubic feet.

This was for a gas of less than 300 Btu per cubic feet, and the estimated cost of the equivalent of 1,000 cubic feet of natural gas was less than 30 cents. In this case the coke was figured at less than $2.50 per ton; and the labor, repairs and maintenance were based on information furnished by the manufacturers of the equipment. The great size of the installation probably accounts for at least part of the decrease in estimated cost of the gas. However, it is the opinion of men engaged in the manufacture of blue gas on a large scale elsewhere, that actual experience would probably show a cost nearer 12-13 cents per 1,000 cubic feet, at least, or 38-42 cents for the equivalent of 1,000 cubic feet of natural gas.

There are at present only a few plants making blue gas for industrial heating purposes. One visited was at the Hawthorne works of the Western Electric Company at Chicago. It was reported by the officials of that company to have given very satisfactory service.

The other possibility mentioned was ordinary producer gas, cooled and cleaned so as to be readily transported for moderate distances and to give little trouble from tar settling in the mains or clogging up the burners. During the past four or five years a great deal of attention has been paid to the question of cleaning producer gas, and some interesting results have been obtained. Many methods have been proposed, and some at least have given pretty good results. Among those suggested the following may be mentioned:

Filtering.

Precipitation by repeated contact with zigzag surfaces.

Rotary scrubber.

Electrical precipitation.

Several plants have been installed to use the filtering system—mostly by the Smith Gas Engineering Company's glass wool filter. Experience with the filtering system seems to indicate that its satisfactory working depends very largely on the way the producer is working. If the latter is at the right temperature, the nature of the tar produced is such as to give comparatively little trouble with the filter; but if the producer gets too hot, or channels too much, the tar becomes very sticky and quickly clogs the filter, causing either trouble with the flow of gas or excessive labor in cleaning the filters.

The zigzag-path precipitator, designed by Flinn & Dreffen, of Chicago, has been installed at a good-sized steel works in Ohio at a total cost, including producers, of about $125,000, the equipment being expected to gasify about 40 tons of coal a day, and clean the gas. However, it has never been put in operation, as the supply of other gas has been sufficient; but the chief engineer reports that he recommended it after seeing it in operation at a small plant in Illinois, and comparing it with several plants cleaning gas by the filter system. The one small plant using his system was getting quite satisfactory results.

The third system of cleaning mentioned was by a rotary washer. It was first mentioned to me by Mr. G. C. Lowell, formerly superintendent of the Gary by-product ovens. He stated that considerable experience in transporting by-product oven gas, by the aid of a booster fan, convinced him that a centrifugal blower was one of the most efficient instruments yet devised for removing tar from gas. Later, it was learned that the Pittsburgh Plate Glass Company had installed two plants of this type; only one of which, however, has been in operation as yet; but it has given excellent satisfaction as regards simplicity, reliability, and economy of operation, effectiveness of cleaning. The installation consists of duplicate units throughout—producer, spray cooling lower rotary scrubber, and booster fan. There is also after the scrubber a box containing excelsior to act as a guard filter; but so little tar is left in the gas after leaving the scrubber that it is only at long intervals that the excelsior is changed. The plant in operation, using one unit, gasifies 20 tons of coal a day. The other plant, not yet operated, was calculated to gasify 40 tons of coal a day with half the units operating and half in reserve; or 75-80 tons a day with all units in service. Exclusive of producers, this equipment cost a little over $100,000.

The rotary scrubber built by the Buffalo Forge Company, in general principle resembles the Theissen washer, so long and successfully used in cleaning blast-furnace gas for gas engine use. The Theissen washer in practice reduced the dust to 0.005 grain per cubic foot of gas. The rotary scrubber is guaranteed to reduce the tar in cleaned producer gas to 0.015 grain, or less, per cubic foot.

Accurate detailed costs of cleaning producer gas by either of these methods could not be obtained, but it was stated that when the cost of raw producer gas was equivalent to 12 cents per 1,000 cubic feet of natural gas, the corresponding amount of cleaned gas from the rotary scrubber cost 18 cents. This indicated that the cost of cleaning was about 0.86 cents per 1,000 cubic feet.

The remaining method of cleaning producer gas mentioned above, is by electrical precipitation; three variations of this method have been proposed. The original one, known as the Cottrell process, uses direct current with intermittent discharge. A modification by a Pittsburgh man, Mr. A. F. Nesbit, uses direct current with continuous discharge, and the process offered by the Steere Engineering Company uses alternating current. Of these three, it was possible to get data as to satisfactory operation from only one installation—that at the plant of the Minnesota Steel Company at Duluth. It is of the Cottrell type, designed in detail by the steel company's engineers to take care of 5,000 cubic feet of gas per minute, and its efficiency is indicated by the following results of a test extending over several days:

	Average.	Maximum.	Minimum
Raw gas, grains of dust and tar per cubic foot	0.0876	0.2162	0.0347
Clean gas, grains of dust and tar per cubic foot	0.0059	0.0110	0.0026

Measurements taken at 28.9 inches, barometer, and 40 degrees F.

It is apparent, then, that the cleaning of producer gas, is neither a difficult nor a very expensive process, and it can be accomplished by at least four different methods. The rotary scrubber apparently does not remove quite as much of the tar as do the filter and electrical precipitation methods, but it is apparently simple and reliable, giving very little trouble in operation. The figures quoted would indicate that the electrical precipitation equipment, if properly designed and installed, will give a more perfect removal of the tar with perhaps equal reliability and simplicity of operation and perhaps at a lower cost.

The cost of raw producer gas, of course, varies greatly, mainly with varying prices of coal, but also with labor conditions and with the type of producer. Inquiries made more than a year ago showed that for conditions existing in 1916, at five typical steel plants the costs of gasifying a ton of coal ranged from 45 to 61 cents with mechanically poked producers, and from 78 to 98 cents with hand poked producers. Costs of coal ranged from about $1.70 to $3.30 per ton, and the costs of gas from 1.6 to 3 cents per 1,000 cubic feet. Converting these figures to the equivalent of 1,000 cubic feet of natural gas, we find them to range from 11 cents, with low priced coal and mechanically poked producers, to 22 cents with hand poking and the higher priced coal. This does not include interest and depreciation charges, amounting perhaps to 0.6 cent per 1,000 cubic feet of producer gas or 4.2 cents per 1,000 cubic feet of natural gas.

Recent figures seem to indicate that at the present prices for coal and for labor, the cost of the raw producer gas equivalent to 1,000 cubic feet of natural gas, in this district, would be close to 25 cents. Cleaning by the above methods would probably add from 5 to 10 cents to this cost.

This analysis would indicate that water-gas is slightly more expensive than clean-producer gas, if we take into account only the costs of production. On the other hand, it requires larger gas mains, a little more power to pump it any considerable distance and, for some of the higher temperatures, requires a more expensive installation in the form of checker chambers.

EDITOR'S NOTE—During the discussion of this paper, Mr. A. E. Blake presented a rather comprehensive set of calculations showing the cost of a blue gas plant. Commenting on these figures he said in part: "It will be seen from the foregoing, that the cost per 1,000,000 Btu by the use of water-gas is 1.56 cents more than the cost per 1,000,000 Btu by the use of producer gas. When one considers the great difference in the two fuels by reason of the great dilution of producer gas by what may be termed deadwood in the form of the nitrogen, which cannot be avoided in the gasification of coal in the formation of producer gas, it will readily be understood that the small added cost of the blue water-gas is nothing in comparison to the advantages to be gained.

FOREIGN RELATIONS

CREDITS TO FOREIGN PURCHASERS.

Attention is called to the vital necessity for granting more liberal credits to foreign purchasers of American products, in a statement issued yesterday by Charles H. Sabin, president of the Guaranty Trust Company of New York. Mr. Sabin advocates the meeting of international competition by the extension of longer credits than we have given heretofore.

Mr. Sabin said:

"The war literally forced us into world markets on a scale never before even dreamed possible. And we are beginning to realize that our national prosperity is very materially dependent upon the continuation of our vastly increased production, which exceeds the requirements of our own market and must continue to find an adequate outlet elsewhere.

"But, owing to the war, other peoples cannot pay us on practically a cash basis for the goods which they want to purchase from us, and which they sorely need. Consequently, we must allow them more time in which to meet their obligations.

"We must revise our point of view about foreign credits. Our banks can no longer restrict such credits to 60, 90, or 120 days, and render to manufacturers and exporters the service which the present readjustment period makes imperative.

"England and Germany built up their great foreign trade prior to 1914 largely by making six months time the selling basis for their goods. If we are to hold our own in foreign trade, we must profit by the experience of other countries and adapt ourselves to the needs of the present situation. The war has taught us many lessons; peace will teach us more. We have learned, for instance, that our existing banking system, predicated upon elasticity, is today probably the strongest in the world. But we now need to develop greater elasticity in our banking methods, particularly in our point of view regarding credits for the fostering of our foreign trade. This is especially demanded in the selling of our manufactured articles overseas, although it holds true to some extent in the selling of raw materials also.

"The unpegging of sterling and franc exchange, recently, has surely made clear to us the condition which is bound to prevail if we continue to insist upon the short term credits which we have held to in the past. When the British and French governments withdrew their support to sterling and franc exchange, respectively, the tendency, naturally, was to put the American dollar at a premium in England and France, which means that it takes more francs and shillings to equal a dollar and, consequently, less imported goods can be purchased for an American dollar in those countries than was possible prior to the unpegging of the exchanges. This will tend to discourage the buying of American goods, and eventually will result in serious curtailment of our foreign trade—unless we counteract that tendency by extending credits for a sufficient period to enable purchasers of our products abroad to pay us at a more convenient time."

MERCHANT MARINE.

The importance of the merchant marine in the development of foreign trade, and facts that the exporter should know concerning the technique of shipping by ocean carrier, are set forth interestingly in an illustrated booklet just issued by the Guaranty Trust Company of New York under the title "Shipping's Share in Foreign Trade Fundamentals of Ocean Transportation." The book is one of the series dealing with export trade which the company is putting out, and is written to meet the needs of the newcomer in the field as well as to provide a handy reference for the experienced trader.

The present publication, which is being sent upon request to interested persons, tells of the war development of the merchant marine of the United States, and its comparative place among the fleets of the countries of the world, and also gives figures showing the development of the foreign trade of the country during the past few years. Factors which must be considered in the determination of freight rates, the functions of "tramp" and privately operated vessels as opposed to liners, methods of computing the capacity of vessels, and similar technical information is clearly set forth.

There is also a passage defining the customary commercial terms used in quoting prices to foreign buyers, and a description of the various papers which the shipper must procure in making an export shipment, as well as of those carried by the master of the vessel.

The practice regarding the "free lighterage privilege" is set forth in another section.

Customs and usages in marine insurance are given special treatment, and the various types of policies are described, together with some statement of the comparative liability of the shipper and the ship in case of damage or disaster.

Finally there is a section devoted to the problem of financing export shipments, with a discussion of the various forms of payment, cash and credit, and the use of the bank acceptance in foreign trade.

Among the other subjects treated are the Principal Ocean Routes, the "Draw-Back" System, the Various Kinds of Marine Losses, the Problems of Profitable Voyages and Shipping, "Conferences" and Coöperation.

The book, which is uniform with other publications of the company, is attractively printed and illustrated.

VALUE OF FOREIGN INVESTMENT.

The tendency today is to over-emphasize the value of foreign investment in developing foreign trade, it is declared in the initial issue of Commerce Monthly, a journal of commerce and finance published by the National Bank of Commerce in New York, which asserts that both good business and good citizenship demand that first place be given to American enterprises and to the reconstruction needs of Europe in the investment of American capital. There is no magic in foreign trade, the bank says, and the theory that investment in foreign countries necessarily results in stimulated export trade to the investing country is called "the great illusion." The article, entitled "Apportioning American Capital," says:

"Our foreign trade policy and our foreign investment policy should be divorced; foreign investments should be concentrated in Europe, while our foreign trade may be expected to expand with non-European countries. The capital of the world is scarce and will be scarce for many years after the war. It must be wisely utilized. As claimants for the new capital of America, the United States and Europe must have first place. This should not, however, preclude American investment in non-European foreign countries where extraordinary opportunities exist. We should seek to apply capital in the places where it will do most good, wherever they are; and not all these places are in the United States or Europe. Just as the general statement that the Rockies are higher than the Appalachians does not mean that all hills of the Rockies are higher than all the hills of the Appalachians, so the generalization that Europe and America must come first as claimants for America's capital does not mean that they should get all of it. But we must remember that America was a debtor country before the war, and that a country undergoing rapid development is insatiable in its demands for new capital. The interests both of American business men and of American laborers are jeopardized if our foreign investment policy goes too far. The argument that we must lend to non-European countries to develop our export trade with them is false. Our trade with non-European countries, both exports and imports, will expand without this stimulus as a consequence of Europe's reduced ability to trade. It is not necessary to take unusual steps to develop the sources of raw materials. Raw materials will be relatively more abundant than finished products for some years following the war, since the destruction of the war has been concentrated in the manufacturing regions. Capital in general is scarce, but gold we have in superfluity and we can make specific gold loans freely.

"Grave responsibility rests on those who choose the foreign investments of a great people. England alone of the major investing countries had really mastered the problem before the war. We dare not substitute enthusiasm for science in dealing with it."

RAILROAD MATERIAL FOR CHINA.

(Vice Consul Raymond C. Mackey, Hankow.)

There is an excellent opportunity in this region for the sale of railway material. Buyers, however, have been laboring under great difficulties, chiefly occasioned by the almost prohibitive cost of railway supplies and inadequate shipping space for the transportation of same. As an example of the great handicap to which railway construction in this region has been subject it may be stated that, due to the impossibility of securing certain rolling stock and machine shop equipment, all portable property previously owned by the I-Kwei or American section of the Hankow-Szechuan Railway has been moved to Hankow. Only roadbed and buildings remain. Much of this property has been resold to the Hankow-Canton Railway, in order that its work of construction might be carried forward.

Most of the materials required are for new developments. In the past America, Belgium, England, and in some cases China, have been the chief sources of supply for railway equipment. Most of the material and rolling stock used by the Hankow-Canton Railway, the Nan-Hsun Railway, and the Hankow-Szechuan Railway is of American manufacture. The equipment of the Peking-Hankow Railway, however, is largely of Belgian origin, although a number of American locomotives have been purchased recently.

The customary method for the purchase of railway material by the various lines in this region is to advertise in the local paper for bids covering the equipment desired. Local firms known to be acting as importers of railway materials are also advised by letter that bids are desired. On the day set the bids submitted are all opened and decision is then made on the merits of the various propositions submitted.

The payment for purchases made is almost without exception on a cash basis, a certain percentage being demanded when the order is placed and the remainder when goods are delivered.

The total value of imports of railway material into Hankow during 1917 was $56,127. There are no local government restrictions the nature of which are to be considered obstacles in any way. Railway materials are subject to various import duties, depending upon the nature of the equipment, but these duties are not excessive.—(Daily Commerce Report.)

FOREIGN TRADE OPPORTUNITIES.

The following foreign trade opportunities are reported in the daily commerce reports. Reserve addresses may be obtained from the Bureau of Foreign and Domestic Commerce, Washington, D. C., and its district co-operative offices. Request for each opportunity should be on a separate sheet and state opportunity number. The bureau does not furnish credit ratings or assume responsibility as to the standing of foreign inquirers; the usual precautions should be taken in all cases.

28838—A firm of commercial agents in Italy desires to secure an agency with a stock of goods for the sale of agricultural implements and machinery, electrical fittings, hardware, such as nails, screws, and locks, shoes, toys, and general merchandise. Quotations should be given f.o.b. New York or port nearest to manufacturer. Cash will be paid. Correspondence may be in English. Reference.

28841—Firms in Ecuador desire to receive catalogs, either in English or Spanish, of electrical materials, wire, lamps, fixtures, etc., and of woolen and cotton goods.

28880—A man in France wishes to purchase or to secure an agency for the sale of machinery for manufacturing machine tools, and electrical supplies. Correspondence should be in French. Reference.

29040—A municipal engineer of a city in France desires to purchase sheet steel, iron bars, and iron and steel bars and rivets, as shown in specifications, which may be examined at the bureau or its district office. (Refer to Exhibit No. 112134.) Correspondence should be in French. These supplies are needed for the port works of this city.

28873—An engineer in Wales desires to secure an agency for the sale of all kinds of engineering tools, supplies, and metals. Terms of payment, cash against documents at bank.

28867—A company in India wishes to purchase three Lancashire steam boilers, 30 feet long by 8 feet in diameter, for 160 pounds steam pressure, and high-class paper-making machinery. A list of the machines desired and their description may be obtained from the bureau or its district offices. References.

29083—A man in Greece desires to purchase galvanized-iron sheets and corrugated-iron sheets, size in meters, two by one thickness; 22 to 28 gauge; and solder used in connection therewith. Quotations should be f.o.b. New York. Correspondence may be in English. References.

29088—An electrical machinery manufacturer in France desires to secure an agency., on a salary and commission basis, for the sale of electrical, metallurgical, or mechanical products. Correspondence may be in English.

29095—A man in Turkey desires to receive from exporters, by cablegram, quotations f.o.b. New York, for cement, steel girders, iron pipe, and pine lumber.

POST-WAR POSITION OF BRITISH STEEL TRADE.

(Special Correspondence, Trade Supplement to the London Times.)

The change over from war to peace-time activity has completely altered the position of the iron and steel industry in the United Kingdom. During the war the home demand for iron and steel was such as to render the industry independent of foreign markets and virtually to exterminate competition. The manufacturers' position was therefore comfortably easy. On the other hand, while they have had to hand over the larger slice of their excess profits to the government in the form of taxation, their foreign competitors—at least the more important of them—have been able to retain the major portion of their correspondingly large profits, and thus to improve and extend their works and plant at little extra capital cost. Now that the war is over and the British manufacturer is face to face with world-wide competition, his position wears a totally different aspect from what it has done during the past few years. He finds that the American manufacturer can quote prices one-third less than his own.

High-grade ore is a vital factor in the economics of the iron and steel industry. Many of the high-grade deposits had been exhausted before the war, and the process of exhaustion has been quickened to satisfy war's demands. The industry is therefore compelled to an increasing extent to rely for its raw material on low-grade deposits and to import high-grade ore, which is obtainable at very high prices. Lack of foresight in securing deposits of high-grade ore abroad in the past is largely responsible for the position in which the British manufacturer now finds himself; but, in view of the national importance of the iron and steel industry, it is suggested that the government secure, directly or indirectly, such deposits as are available abroad and hold them until they are required by the exhaustion of other deposits.

Meanwhile, the manufacturers are taking steps in two directions for improving the position of the industry. First, they are urging the government to allow them to retain, say, for 10 years, their excess profits duty, now unpaid, free of interest, provided these sums are used in betterments and extensions. It is suggested that the manufacturers should pay off their liability to the government in 10 annual installments. The government would lose very little by this arrangement, while the manufacturers would be able to bring their plant up to date, so as to enable them to get level with their competitors.—(Daily Commerce Report.)

PRODUCTION TOPICS

PROPER LUBRICATION OF AIR COMPRESSORS.

(Continued from page 226)

at same piston speeds, as given in Table No. 3, the recommended amounts to feed the steam cylinders or their equivalents are given in the following:

Table No. 5—Quantity of Oil for Steam Cylinder Lubrication.

No. Drops Per Minute	Size of Cylinder Inches	Number Pints Oil Required per 10 Hours
4	8 x 8	.4
8	12 x 12	.75
16	18 x 18	1.5
24	24 x 24	2.25
32	30 x 30	3.0
40	36 x 36	3.75
48	42 x 42	4.5

These figures are approximate only, and will vary with the steam conditions, the kind of oil used, and its method of introduction into the steam, also with the boiler compound carried by the steam into the cylinder.

Observations on Changing Tested Oils.

When the operator of an air compressor succeeds in obtaining lubricating oils that are giving satisfactory results, he should be very cautious about making a change to other grades, particularly if cheapening the cost is advocated by purchasing and sales agents. But if a change is decided on, the performance of the new lubricants should be most carefully checked up before damage can occur to the rubbing surfaces of the compressor, and to see that no increased amount of deposit collect on the inside walls of the air receiver.

The most satisfactory way to get the quickest results is to put up the problem of lubrication to the local experts of any reputable lubricating company, and to be governed by their recommendations, which, however, should be based on the foregoing statement.

IRON AND STEEL CHART AVAILABLE.

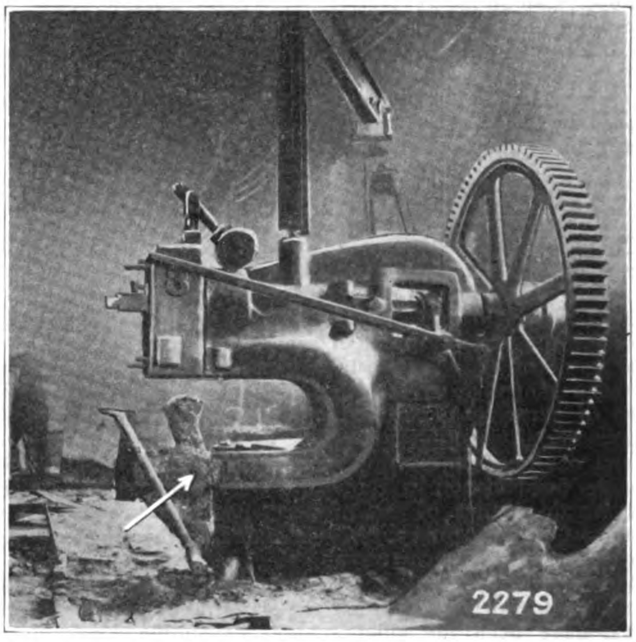
C. S. Dickerhoff, Jr., 749 Turner street, Allentown, Pa., has recently completed a chart on iron and steel showing the seven different processes; namely, open hearth, Bessemer, electric furnace, puddling, crucible, cupola and air furnace. This chart follows the manufacture of iron and steel from the blast furnace to the finished product. A complete list of products including typical analysis made by these processes is appended to this chart. This diagrammatical representation of iron and steel manufacture will be found exceedingly interesting to the student or operating official. Copy of this chart may be secured by communicating directly with Mr. Dickerhoff at the above address.

CAST IRON THERMIT SHEAR WELD REPLACES BRAZING FAILURE.

Reliability proved to be the real economy factor in a successful thermit weld recently made on a cast iron shear housing for the Independent Bridge Company, Pittsburgh, Pa., after a failure in attempting to weld the large break by a brazing process. The finished thermit weld is shown in the accompanying illustration.

The brazing process, consisting first in bolting the broken parts of the shear, then brazing them, had consumed about three weeks in executing a weld. The shear was then installed, but it ran only a few hours when the housing broke again, through the portion brazed. It was then decided to repair the break by the thermit process.

It was necessary to chip the old weld out entirely which made a larger weld than necessary, had the machine been thermit welded at first. The thermit welding required only two eight hour days, an additional half-day having been taken for stripping the mold. Eight hundred pounds of cast iron thermit were used in two No. 10 or 34 inch diameter rim automatic crucibles.



Successful thermit weld made on cast iron shear housing.

The housing was quickly replaced in operation and, at last reports, was back at its heavy work in cutting corners out of plates about ¾ inch thick and 3 inches square.

JAPANESE REQUIREMENTS.

(Consul Max D. Kirjassoff, Taihoku, Taiwan, Formosa.)

Rails are always in demand here, especially light rails from 12 to 30 pounds in weight. Heavier weights are used only by the government railway bureau, which obtains its supplies chiefly from the Imperial Steel Works of Japan. The bureau also builds most of its own railway cars in Taiwan.

Sugar mill extensions and the opening of new coal fields should insure continued demand for light rails, Germany and the United States having been the chief sources of supply for this material in the past.

Both the government and the industrial establishments almost invariably make their purchases through local agents. The customary method of payment is by credit opened in New York, with drafts at four months. Rails are usually bought by the mile of single track. The government railways have a gauge of 3 feet 6 inches, those of the Bureau of Forestry and of private firms are 2 feet 6 inches.—(Daily Commerce Report.)

The Apollo Steel Company, Apollo, Pa., is planning for the early operation of its two new 30-inch sheet mills under course of construction for some time past. These new rolling mills will provide a total of eight hot mills and two cold mills at the works. The equipment is operated by a large motor-controlled gear.

NEWS OF THE PLANTS

Effective July 1, the Liberty Steel Compny, Warren, O., will be merged with the Trumbull Steel Company, Youngstown, O., with works also at Warren. The Trumbull company will take over the Liberty plant, which now comprises eight sheet mills and will use the works primarily for the production of steel sheets and tin plate. The acquisition will give the Trumbull company a capacity of about 360,000 tons. At the Liberty plant, plans are under way for the installation of four new sheet mills to largely increase the present output. It is also understood that other extensions and improvements will be made.

The Tennessee Coal, Iron & Railroad Company, Birmingham, Ala., has completed the construction of its new plate and structural mills at Fairfield, Ala., which have been in course of erection since late in 1917. The plant is located about one mile from the company's by-product coke works in this vincinity, and consists of a 45-inch blooming mill, a 36x110-inch plate mill, and combination bar and structural mill. The site provides considerable additional land for proposed later extensions of blast furnace and steel works. The 45-inch blooming mill adjoins a furnace building about 75x450 feet, and has a lift of 52 inches with the top roll electrically-operated. The main mill building is about 75x560 feet, while the motor house, located on nearby ground and now practically completed, will be about 60x320 feet. The mill has two hotbeds located in a building about 90x180 feet, while adjoining is the straightener building, with equipment including a 15-ton crane. The plate mill is driven by a 4,000-horsepower motor, and is fully equipped in all features of operation. The building in which the mill is housed is about 60x400 feet, and provided with a 50-ton overhead traveling crane. The structural and bar mill consists of one stand of 3-high rolls, 28-inch, three stands 26-inch, and two stands 24-inch. The roughing mill is operated by a 25,000 horsepower motor, while the 26-inch and 24-inch trains are driven by 3,000 horsepower motor. The plant also comprises a group of shops for steel fabrication for shipbuilding work. These different structures comprise plate shop, machine shop, foundry, forge shop, rivet and bolt shop. The plate shop is about 350x630 feet, and is fully equipped for punching, shearing, and other operations used in connection with the production of plates and shapes for ship hull construction. The machine shop is about 85 feet wide, with leanto about 40x75 feet; the forge shop also is of this width, and 240 feet long, with leanto extensions. The bolt and rivet shop is about 65x160 feet, with a leanto 50x65 feet. This building is provided with machinery for the manufacture of bolts, nuts, rivets, and other small items necessary for production. The foundry will be used primarily for the production of gray iron castings. The material from this plant will be used by the company at its shipbuilding works at Mobile, Ala., as well as by the Chickasaw Shipbuilding Company located in the same district.

J. C. Cromwell, Guardian Building, Cleveland, O., has leased the plant of the Cromwell Steel Company, Lorain, O., for a period of 99 years, and plans to inaugurate operations for the production of steel bars at an early date. This production will include material from about 3 to 8 inches in diameter, and of carbon steel and various alloys. The plant, which will be operated in Mr. Cromwell's name, comprises four 90-ton open hearth furnaces, roughing mill, finishing mill, and a number of other structures. The plant has been closed since early in the present year. W. S. Greenawalt has been appointed superintendent.

The Monongahela Tube Company, Pittsburgh, Pa., has resumed operations at its plant after a period of partial inactivity to allow for new construction and repair work. The plant is located at Wilson, Pa., and the new installation includes welding furnaces, reversing engines, and other machinery.

The American Sheet & Tinplate Co., Pittsburgh, Pa., is planning for improvements and extensions in its plant at Farrell, Pa., to cost about $500,000. A majority of the construction work will include the erection of a coppras plant to replace the structure destroyed by fire; the structure, with equipment, is estimated to cost about $400,000, and will be of brick and steel type. The company will also construct a restaurant building for its employes to cost about $90,000.

The Pennsylvania Steel & Iron Corporation, Lancaster, Pa., is considering plans for the construction of extensions to its plant during the present year to cost in the neighborhood of $65,000. The work contemplated includes the addition of four new heating furnaces to the 8-inch and 10-inch mills, and the construction of a new building for the 8-inch mill. Other minor improvements and betterments will be made to increase the operating facilities.

The Ludlum Steel Company, Watervliet, N. Y., has recently completed a number of additions to its plant, to increase the capacity as well as operating facilities. The installation includes two new 6-ton electric furnaces, provided with a 10-ton crane, making a total of eight electric furnaces at the plant, as follows: Three 10-ton, three 5-ton, and two 6-ton. A new annealing shop has also been completed with installation consisting of six 15-ton annealing furnaces, and it is planned to add two more furnaces of this type at a later date. The company has also recently placed in operation a new grinding department, to be used almost exclusively for the grinding of high speed steel billets. The installation, including an adjoining grinding building, comprises 36 grinders. The company has increased its output by about 50 per cent with these different installations, and it is understood that plans are being considered for still further expansion in production facilities.

The Empire Steel & Iron Co., Catasauqua, Pa., operating plants at Mount Hope and Oxford, N. J., as well as at Macungie and Topton, Pa., is planning to shut down the furnace at the latter plant at an early date, to provide for general repairs. The company is also planning to make repairs at its Crane Iron Works plant furnace. During the past year, a total of 204,297 tons of pig iron was produced at the different plants, while the ore mined by the company aggregated 255,945 tons.

The Sharpville Furnace Company, Sharpville, Pa., has recently closed down its blast furnace for an indefinite period. It is proposed to keep the plant idle until sufficient orders mature.

The Whitaker-Glassner Company, Wheeling, W. Va., is considering plans for the early operation of its steel works at Martins Ferry, O. Six mills at this plant have been idle for some time past.

REPORT OF MEETING HELD BY ELECTRIC FURNACE ASSOCIATION.

On the afternoon of Thursday, April 3, a meeting of the newly formed Electric Furnace Association was held at the Chemists' Club, 50 East Forty-first street, New York City, at the call of the president, Mr. Acheson Smith, and a large number were present. Reports of the various standing committees were made, and a tentative draft of the constitution and bylaws submitted. Resolutions were passed adopting the constitution as drawn for a temporary period until the new membership committee, which is to be created at once, can secure a representative list of members from the various industries interested in the work of the association.

INDUSTRIAL RELATIONS

DISABLED SOLDIERS RETURN TO INDUSTRY.

By Sue Michaels.

A very interesting and forcible illustration of the value of cripple labor is furnished by the case of an American contractor who was asked in February, 1917, to go to Toronto to superintend the erection of the largest steel plant in the world. In a letter to the Red Cross Institute for Crippled and Disabled Men of New York City, telling of his experience with the returned soldier, he writes as follows:

"In February, 1917, I was asked to go to Toronto, Ont., Can.,, to superintend the erection of the largest electrical steel plant in the world, comprising furnaces, building, presses, saw shop, railways, etc. The work was started on February 22, 1917, and we were sawing shrapnel bars and pressing 9.2 shells June, 1917, and on July 15, 1917, we were making steel, thereby making a world's record on construction. The entire plant was erected at a cost of $4,000,000.

"When I first went to Toronto in February, 1917, I noticed a great many returned soldiers on the streets and the thought struck me, why not try them out on construction work. With this in mind I commenced to build up an organization of returned soldiers. I had men with one leg, one arm and one eye, shell shocked and gassed men. Altogether I had about 800 returned soldiers mixed with civilian workers and out of that number only 17 were discharged for not attending to their work. This proves that the returned and crippled soldier given a chance will work well and faithfully. To these men with their wonderful discipline, their quickness in obeying orders and their loyalty was due the splendid world's record in construction. They not only made a record as fighting men in France, but given a chance made further record in the industrial world.

"Of course, a little patience has to be used at first but the men soon get used to the change and will respond quickly to kindness, sympathy and justice, and these they must have. They do not want coddling or charity, but a chance to get into the swing of civil life again. The hero-worshipping public should be discouraged as they too often spoil a good man. While their intentions are good, they are often misunderstood.

"* * * A good many of the discharged soldiers that could not work at their former occupation and did not know what to do are the men I picked up and helped. For instance, a man who had worked in the woods, a lumber jack, badly wounded in the feet and legs also having a plate in his skull, made a very good lathe hand without any other training than being a helper in the machine shop. One who had charge of the cutting department in a tailor shop turned into a very good shipping clerk in the plant. This man was hit by shrapnel in the back and also gassed. A head waiter in a hotel, badly gassed, made a good cost clerk, etc. * * *

"It is a very interesting study and I think the sooner the public, and especially the employer of labor, is awakened to the fact that there are big things that are still expected of them when our wounded and sick come home, the better for all concerned."

Whatever may have been the attitude toward the war cripple in the past, the attitude toward them today shall be not merely hero-worship and compensation but a position and a chance to make good. This attitude has expressed itself in the modern plan of reconstruction—of training men in the use of their remaining faculties or the use of artificial limbs, and teaching them thoroughly some well paying trade.

There are any number of trades that can be successfully taught. In the case of a leg cripple, the possibility of doing work seated, or his ability to stand for a while without becoming tired is the only consideration that need enter into the choice of a trade. Even the arm cripple has a wide choice, made possible by the "working prosthesis"—a simple chuck in which may be fitted special tools designed for the trade in which the worker is to engage. Such inventions permit men to use machines, work at power presses, do sawing, screwing, boring, and to become lathe hands. They could thus easily be employed in blast furnaces and steel plants.

However, it is not only for arm and legcripples that re-education is provided and employment sought. Such cases form but a small number of those whose physical powers have been impaired by the war. Men suffering from shell shock, blindness, deafness, tuberculosis, rheumatism or some internal injury, also frequently require readjustment and care in placing.

America could not be a strong social and economic force were she to allow the incapacitated to drift into an army of non-supporting, helpless human being. Through an act of Congress every soldier disabled in the military or naval forces of the United States has been placed under the joint authority of the surgeon general of the Army and the Federal Board for Vocational Education.

The disabled soldier's re-education is begun while he is still under doctor's care. The reconstruction hospital is the newest kind of hospital. It combines at once, hospital, convalescent home and vocational training school. A carpentry or machine shop is usually attached to the reconstruction hospital. This serves several good ends. It provides a form of exercise which has been found by surgeons to hasten recovery of the use of paralyzed or stiffened limbs, and to give back to the crippled soldier his self-confidence. A carpenter with a stiff elbow is advised to go to the carpentry shop and use the plane for a certain length of time each day. A locksmith with the same disability is told to use a file. This is more interesting and therefore better medicine than a similar amount of formal gymnastics. It gives the skilled man the opportunity to again accustom himself to the use of tools and machines and to the unskilled man it may give just the amount of training necessary to fit him for some particular job.

When the soldier is in good physical condition he receives his honorable discharge from the service from the surgeon general of the Army. Should he then require thorough training in any kind of work, this is provided through the Federal Board for Vocational Education. While training, the government pays him an allowance equal to his last month's salary while in service, or his compensation for disability, whichever is larger, and an allotment is also paid to his family just as though he were still in service. This is to relieve him of financial worry while he is learning a new trade.

Very remarkable progress has been made in the re-education of the physically handicapped at the Red Cross Institute for Crippled and Disabled Men of New York City. The work of the institute was started in May, 1917, with the industrial and civilian cripple to pave the way for the war cripple, and in order to demonstrate that if properly trained and carefully placed in positions, the crippled man could compete with the ablebodied. A survey was made of a great many industries in an endeavor to interest the employer in the placement of cripples and also to study the adaptability of cripples for work.

An employment bureau was established at the institute for the two-fold object of giving employers reliable and competent employes and of providing the cripple with permanent employment. Physician's advice is obtained in connection with assigning a cripple to a position and the institute keeps in touch with the man after he is employed. Thus difficulties and mistakes in regard to class of work and service required are prevented.

Some Pointers on By-Product Coke Oven Operations

EFFECT OF "DIRECT" AND "INDIRECT" AMMONIA RECOVERY UPON OTHER BY-PRODUCTS.

By Thomas B. Smith
Stocksbridge Coke Ovens, Sheffield.

PART II.

At this temperature creosote oil is an excellent solvent and when sprayed into the tubes will absorb the precipitated naphthalene, the heavy naphthas, and the phenols, but will leave the lower-boiling fractions, which are cooled further and pass to the benzol scrubbers. There are three modifications in use of this method, these being in the final treatment of the salty oil.

(a) The first method, which necessitates the presence on the plant of a tar distilery, is to circulate a quantity of oil through the condensers, until saturated with naphthalene, and then transfer it to the tar plant for redistillation and the recovery of the absorbed constituents, the oil being returned to the condensing plant for further use.

(b) The second method is to separate out the napthalene from the salty oil by allowing the later to cool in shallow pans. These two methods, however, were found to be quite inadequate, since the oil, half saturated with napthalene, etc., is only half as efficient as fresh oil, and the nearer to saturation the farther from absorbing efficiency.

(c) A third method was therefore introduced, which not only meets the originators' requirements, but also holds out considerable possibilities for the recovery of by-products at the benzol plant. This method, which we can call the "compensation method," has been in use on various plants for a few years quite successfully. The usual procedure is to spray the last condenser with denuded oil, which afterwards, together with condensed water, runs into a common separating tank connected to all the condensers. The oil is decanted into an oil sump, whence it is pumped to the first condenser sprays, and the water passes to the quencher ponds.

In order to keep the quantity of spray oil constant, it is necessary to withdraw from the oil sump an equal quantity to that of the fresh oil added to the final condenser, this being added to the benzolized oil on its way to the benzol still. By this means fresh oil is constantly added to the spray oil and an equal quantity of moderately salty oil withdrawn. The naphthalene, heavy naphtha, and phenols are distilled out by the benzol still, and should be treated according to circumstances. With an ordinary still and condenser the benzol works chemist has to choose whether he shall make low-strength benzol or leave these intermediate substances in his wash oil (the latter usually having a disastrous effect upon its washing efficiency). Where a rectification plant is attached, he would choose the former, but where the crude benzol has to be despatched as 65 per cent to another firm for rectification, other expedients have to be used. The Simon-Carves plant is unique in its method of raising the strength of the benzol while completely stripping the oil. Complete denudation is effected in the still, the light vapors being dephlegmated from the creosote, naphthalene, cresols, heavy naphthas and the bulk of the condensed water, in a primary condenser, the outlet temperature of which is maintained at tionation still. The sodium cresylate should be "sprung" about 92 degrees C. The intermediate substances are led to a separating tank, where the water is removed, the oil being then cooled in shallow pans for the recovery of the naphthalene.

At a number of plants the cooled oil is returned to circulation. This is a most serious mistake, since it considerably reduces the benzol saturation point of the wash oil. The most valuable constituent of this mixture of intermediate substances is from 7 to 10 per cent of phenolic bodies, which at the present market price is an item of considerable importance. It should therefore be treated at the tar plant. In nearly every case where a rectification plant is in use, the management has recognized the advantage of making low-strength benzol, but it cannot be said that they have recognized the increased advantages where the "direct" process is also installed. When low-strength benzol is made, where the "direct" process is in use, the analysis shows from 3 to 7 per cent of cresols, which in the ordinary method of rectification are left in the residue from the fractionation still, and get back into the wash oil.

The crude benzol is pumped from the storage tank to the fractionation still in one stage. Where the percentage of cresols warrants this, it is suggested that it be pumped instead to the washer, and washed with 40 degrees Tw. caustic soda solution, running the sodium cresylate solution to a storage tank and the washed benzol by gravity to the frac- in a lead-lined washer in the open air, since the dilute acid attacks the ordinary cast iron benzol washer, and also the vapors of cresylic acid affect the eyes very considerably. It is therefore by far the best to sell the solution as such or "spring" it at the tar plant.

Cyanogen Recovery.

It is now quite a commercial proposition to recover cyanogen from coke-oven gas. The "Bueb" process, which is in operation at a number of plants in America, is perhaps the best suggested. This is to scrub the gas before entering the ammonia saturator with a 25-30 per cent solution of ferrous sulphate, which combines with the cyanogen, sulphureted hydrogen and ammonia. The resulting solution and precipitate are acidified and heated to drive off the sulphureted hydrogen, being afterwards filtered and the precipitate pressed. The resulting yield is the double ferro-cyanide of ammonia and iron, and ammonium sulphate, the latter substance being removable by washing with warm water. A considerable number of difficulties have, however, been met with in scrubbing the gas before the saturators—by its effect on the sulphate of ammonia, by mechanically-carried-over products of the above reaction into the saturator, and by the various impurities found in the cyanogen compound formed. Cyanogen and sulphureted hydrogen, if anything, are purified by the acid in the saturator, being thereby liberated from combination with other elements. These gases are therefore left, in the "direct" process, to travel in a free state through the cooling and scrubbing plant back to the ovens. By recovering the cyanogen after the saturators, ultimate products could be obtained of greater purity than those obtained in the "indirect" process.

The complete analysis of a few samples of rich oil taken on its way to the benzol still shows a varying but large percentage of cyanogen and sulphureted hydrogen, proving that creosote oil has the property of dissolving these gases.

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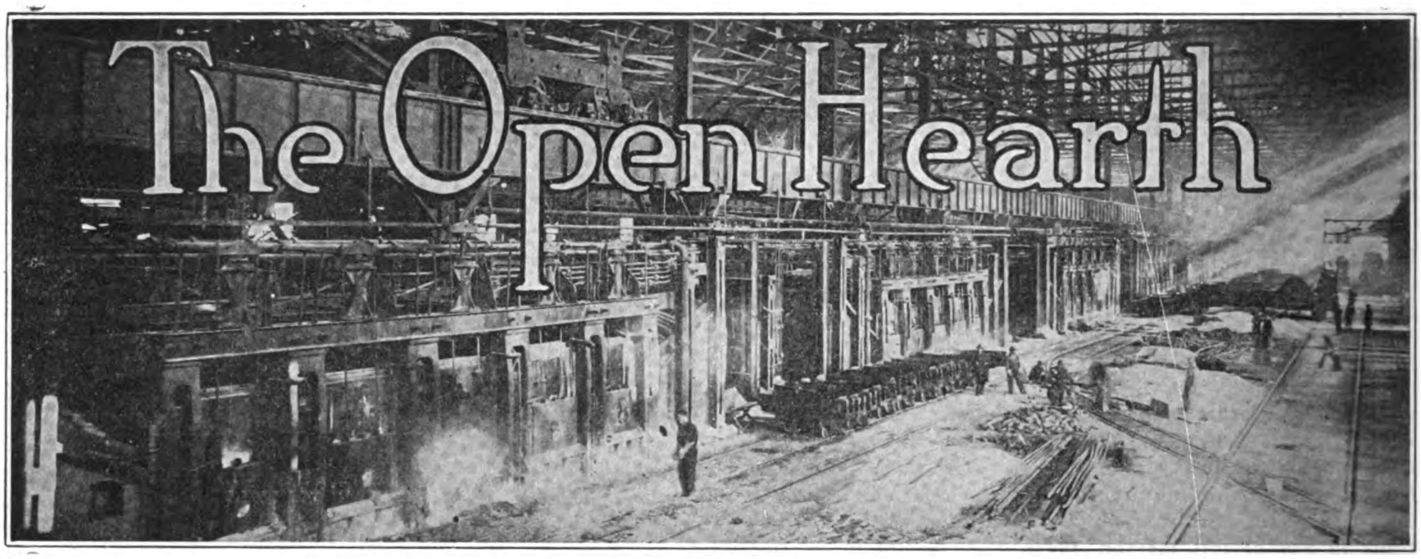
*Abstract from Iron and Coal Trades Review of paper read at Sheffield on December 21 before the Coke Oven Managers' Association (Midland Section).



The Open Hearth

Harold C. Bement is now in charge of the new Onondaga Steel Company's plant at Eastwood, New York. Mr. Bement was formerly connected with the government arsenal at Watertown, Mass., as melter foreman.

√ √

F. E. Lucas is now economy engineer of the Dominion Steel Corporation, Sydney, N. S. A. L. Reading becomes superintendent of the rail mill; W. Buckley, assistant superintendent; W. Walshaw roll designer; C. C. Graves, superintendent of the blooming mill and S. Green superintendent of night mills.

√ √

J. M. Borrowdale has been appointed sales representative in the railroad department of the Liberty Steel Products Company, Inc., with offices in the McCormick Building, Chicago. Mr. Borrowdale has for the past two years been connected with the Johns-Manville Company. Previous to this time he was superintendent of the car department of the Illinois Central.

√ √

Harvey L. Barnard is now superintendent of production of open hearths at the Pittsburgh Crucible Steel Company, Midland, Pa. He was formerly with the United Alloy Steel Corporation at Canton, O.

√ √

Donald H. Gordon, formerly in the sales department of the Republic Iron & Steel Co., Youngstown, now occupies a similar position with the Brier Hill Steel Company.

√ √

E. L. McGraw, who retired from the position of purchasing agent of the Allegheny Steel Company, Brackenridge, Pa., due to illness, has resumed his former position. Mr. McGraw has been absent from this position for more than a year.

√ √

Grayson M. P. Murphy has been elected director of the Bethlehem Steel Corporation, replacing Nelson D. Jay.

√ √

W. A. Early has been promoted from works auditor of the Jones & Laughlin Steel Company to auditor of the company.

√ √

I. H. Cohn is now in charge of the rail department of the Standard Rail & Steel Co., St. Louis. Mr. Cohn was formerly connected with the National Steel Rail Company.

√ √

Gilbert L. Lacher succeeds Charles Lundberg as editorial representative in the Chicago office of the *Iron Age*.

√ √

Donald M. Ryerson, after two years of service in the Navy, has again resumed his duties as vice president in charge of purchases and sales, of Joseph T. Ryerson & Sons Co., Chicago, iron, steel and machinery merchants.

Joseph A. Doyle, who has for a number of years been chief clerk and assistant paymaster at the Woodlawn plant of the Jones & Laughlin Steel Company, has been promoted to general plant auditor of that company with headquarters in Pittsburgh.

√ √

John C. Ogden has resigned his position as general superintendent of the Cambria Steel Company's works, Johnstown, Pa.

√ √

A. D. Neeld, Jr., is in charge of the new sales office of the Badenhausen Company, Jenkins Arcade, Pittsburgh.

√ √

William Bischoff has accepted a position of assistant general superintendent of the Lukens Steel Company, Coatesville, Pa. Mr. Bischoff was formerly assistant general superintendent of the Dominion Iron & Steel Co., Ltd., Sydney, N. S., previous to which he was connected with the Bethlehem Steel Company.

√ √

E. W. Strong has been appointed general sales manager of the Erie Crucible Steel Company, Erie, Pa. Mr. Strong was formerly manager of publicity and of the research department of the American Vanadium Company, Pittsburgh, and was also sales manager of the LeMoyne Steel Company, Pittsburgh.

√ √

E. Ellsworth McCormick, formerly purchasing agent of the Standard Process Steel Corporation, Phillipsburg, N. J., is now connected with the Mesta Machine Company, Pittsburgh, Pa.

√ √

Ralph P. Zint is now vice president of the Concrete Specialties Company, 15 Broad street, New York. Mr. Zint was formerly manager of the steel department of the Swiftsure Export Corporation, New York, and was also affiliated with the Carnegie Steel Company, Republic Iron & Steel Co., and the Federal Export Company.

√ √

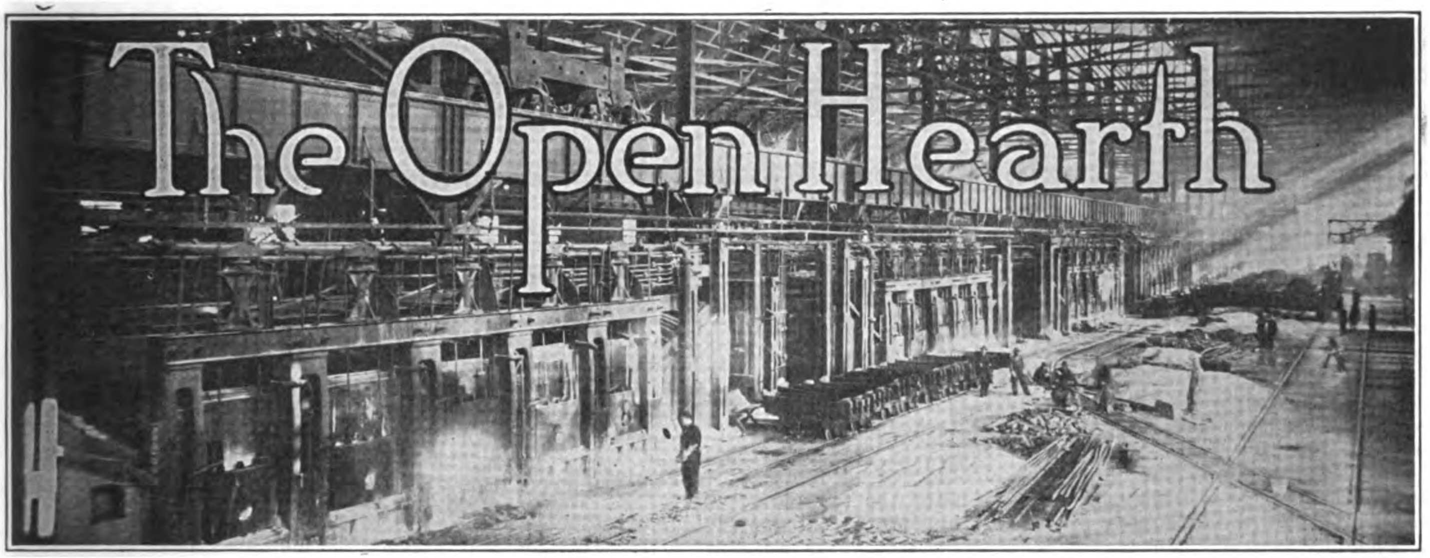
James Lloyd succeeds J. E. Daily as general superintendent of the Lowellville plant of the Sharon Steel Hoop Company. Mr. Daily resigned some weeks ago on account of ill health.

√ √

W. B. Parry, formerly mill superintendent at the Lowellville plant of the Sharon Steel Hoop Company, has been appointed to the position of general superintendent.

√ √

Arthur L. Humphrey has been elected president of the Westinghouse Air Brake Company, Pittsburgh. Mr. Humphrey has been vice president and general manager for the past 10 years.



Thomas F. Willoughby is now advertising manager of the H. H. Robertson Company, Pittsburgh, formerly the Aspromet Company.

V V

George Hills has resigned his position as manager of factory sales of the American Rolling Mill Company, Middletown, O., and will assume the position of general manager of the General Tractor Company, Cleveland.

V V

Alfred A. Corey, Jr., who has been general superintendent of the Homestead works of the Carnegie Steel Company since May 1, 1914, succeeds E. E. Slick as vice president in charge of operations of the Midvale Steel and Ordnance Company and vice president and general manager of the Cambria Steel Company. Mr. Cory has had 26 years experience in the operating phase of the steel industry.

V V

T. W. Holt has accepted the position of general manager of the Curtin Supply Company, Chicago, Ill. Mr. Holt was formerly superintendent of the shell forging department of the Pressed Steel Car Company, McKees Rocks, Pa.

V V

C. R. Bulley has been appointed sales metallurgist for the Hess Steel Corporation, Baltimore.

V V

Lieut. Col. Merrill G. Baker has been elected president of the American International Steel Corporation, New York. The American International Steel Corporation is a subsidiary of the American International Corporation. Mr. Baker succeeds the late Edgar M. Hagar.

V V

H. O'Bleness, assistant to L. M. Burnett, assistant to Homer D. Williams, president of the Carnegie Steel Company, has resigned to become assistant to the president of the Midvale Steel & Ordnance Co., of Philadelphia.

V V

Ensign Fred D. Rice, J. S. N. R. E., recently returned from France, is now connected with the Hess Steel Corporation.

V V

Charles A. Heil has been appointed Cleveland district manager for the Carpenter Steel Company, Reading, Pa., succeeding James W. Sederquist, resigned.

V V

The Ohio Seamless Tube Company, Shelby, O., announces several changes in its personnel: Judge Edwin Mansfield, chairman of the board; R. C. Skiles succeeds H. E. Brubaker as assistant general manager; G. L. Reichert succeeds J. A. Brubaker as secretary and treasurer; R. R. Johnston succeeds H. E. Brubaker as superintendent; S. D. Inscho, maintenance engineer; F. L. Benham, purchasing agent and chief of order department.

John R. Oursler succeeds A. A. Corey, Jr., as general superintendent of the Homestead Works of the Carnegie Steel Company.

V V

L. B. Weidlein, formerly with Ohio Works of the Carnegie Steel Company, at Youngstown, O., is now associated with the Arthur G. McKee Company, at Cleveland. Mr. Weidlein is one of the inventors of the new dry gas cleaning device described in the last issue of THE BLAST FURNACE AND STEEL PLANT.

V V

W. A. Maxwell is now assistant general superintendent of the Cambria Steel Company, Johnstown, Pa. Mr. Maxwell was formerly open hearth superintendent of the Homestead works of the Carnegie Steel Company.

V V

H. A. Berg, formerly assistant superintendent of the Carrie furnaces of the Carnegie Steel Company, is now superintendent of the blast furnaces of the Cambria Steel Company.

V V

Russell C. Gebert is now chief metallurgist and superintendent of heat-treating at the Hammond Steel Company, Syracuse, N. Y.

V V

W. H. Taylor, president of the Iron Age Publishing Company, has sailed for Europe. He will spend several weeks in England and France.

V V

R. E. McMath is now secretary of the Bethlehem Steel Company, and the Bethlehem Shipbuilding Corporation, Ltd.

V V

R. C. Skiles is now assistant general manager of the Ohio Seamless Tube Company, Shelby, O., succeeding H. E. Brubaker.

V V

J. I. Thompson, chief engineer of the Koppers Company, Pittsburgh, and A. W. Grant, Jr., gas engineer of the company, left for Europe recently on a business trip in the interest of the company.

V V

C. B. Connelley, dean of the school of applied industries, Carnegie Institute of Technology, Pittsburgh, who has been appointed state commissioner of labor and industries, will leave shortly for Harrisburg, to take up his new duties.

V V

Leo G. Smith has accepted the position of general manager for the Modern Steel Casting Company, Milwaukee.

V V

Victor E. Rehr, formerly sales manager of the Trumbull Steel Company, Warren, O., now is general manager for the Aetna Foundry & Machine Co., that city. He has secured an interest in the company as has M. C. Boyd, secretary and treasurer of the Heltzel Steel Form & Iron Co.

WITH THE EQUIPMENT MANUFACTURERS

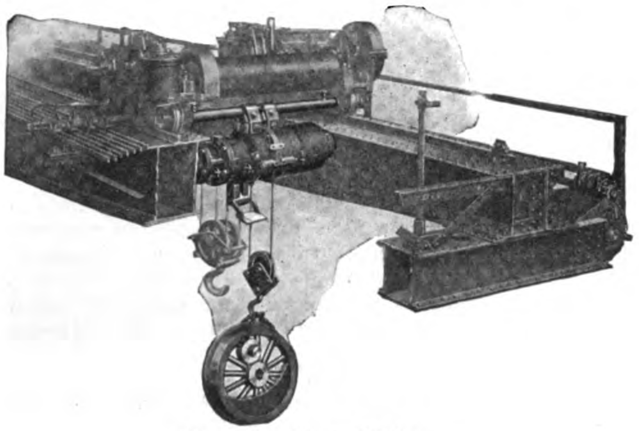
A PATENTED AUXILIARY HOIST FOR TRAVELING CRANES.

A simple and practical auxiliary hoist for attaching to any standard overhead electric traveling crane, as shown by the illustration, has recently been developed by the N. B. Payne & Co., 25 Church street, New York City.

The crane lends itself to quick and easy attachment as it is claimed by the makers that it can be attached "the day it arrives."

The hoist does not take up any more room overhead, does not require an extra trolley, does not shorten the travel of the trolley on the bridge, nor does it interfere with the accessibility of the main hoist. It is plain that these advantages involve a considerable money saving.

It is pointed out by the manufacturers that the average traveling crane in a day's work usually handles a far greater number of light loads than heavy loads, and this is an important point worthy of investigation. Since cranes for lifting heavy loads are slow-moving, their use results in a serious loss of time if they also handle the light loads. Thus a 20-ton crane, direct-current, with a hoistng speed of 12 feet per minute per load will handle a three-ton load at but slightly greater speed. But with the auxiliary hoist a light load of say three tons may be handled at the very much higher speed, two to ten times as fast as the speed of the main crane.



New Auxiliary Hoist.

Attachment of this auxiliary also effect an important power saving. Very often the hook and block of the main crane together weigh more than some loads frequently handled. The auxiliary hook and block being much lighter it is evident that the power saving in a year's time becomes a worth-while item. The labor saving with the auxiliary hoist is another important item, especially when a gang of men must wait for a small piece being slowly moved by a large crane. This is a vexing circumstance with which many foremen are well familiar. The auxiliary eliminates this labor loss.

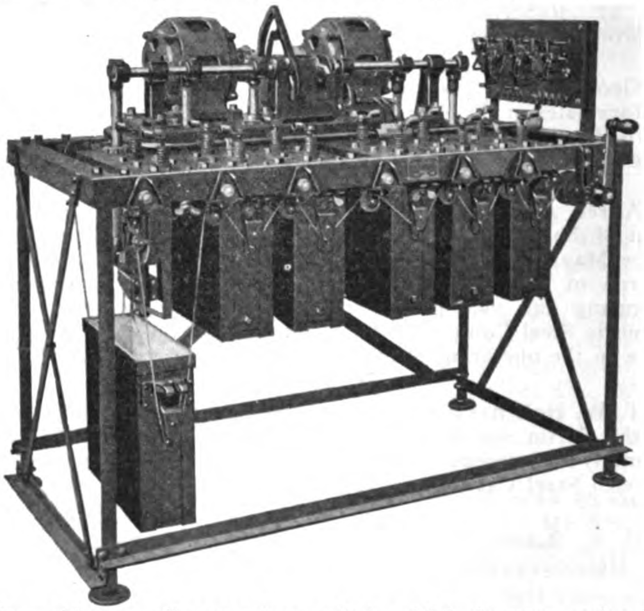
Ordinarily from one to five tons standard auxiliary hoists are supplied by the makers to meet the usual requirements. Larger special sizes, however, are furnished where specified.

Also, by the application of this auxiliary attachment any standard single hoist electric traveling crane may be equipped with two lines for drop bucket service. The control may be arranged from cage, floor or pulpit to suit the crane to which to is applied. It is stated that this auxiliary can be attached by the purchaser, but to assist the manufacturers such information as this should be given: Kind of service; make and types of crane; span; lift; alternating or direct-current motors; voltage; phases; cycles; cage, floor or pulpit control; speed in feet per minute of main hoist at full-load and no-load; approximate weight of average crane load; number of lifts per day; maximum capacity of auxiliary hoist desired; speed in feed per minute desired at full load.

It is evident that this device will prove of much value to present owners of old slow cranes.

NEW OIL REVERSING SWITCH FOR LARGE MOTORS.

High voltage slip ring motors built for steel mills, mine hoists and similar duty, require some form of switch to connect the primary winding to the lines, especially so when the motor is used for reversing service. The accompanying illustrations show a new primary oil reverse switch that has several new and interesting features. It consists principally of two 3-pole switch units each operated by a high torque motor.



New primary oil reversing switch which is very quiet in operation, being operated by two high torque motors.

Among the unique features of this switch are the unit tank construction and the means of lowering the tanks for inspection, repairs and renewal of oil. Unit tank construction is used because it increases accessibility and saves time and labor in locating trouble and making repairs. A double windlass with cables and pulleys permits easy lowering of one or more tanks. In the end view one of the tanks is lowered and shows the simple construction of the stationary and moving members. It will be noted that the arc is broken horizontally rather than vertically. This construction allows the arc to rise to the point of rupture without burning parts not designed for such duty; and since the rupture takes place near the top of the oil, it is well away from all sediment; hence frequent inspections and renewals are unnecessary. The support for the stationary and moving members is bolted to a channel iron which in turn is bolted to the main frame, consequently in case of serious damage to any single pole unit the complete unit may be removed without disturbing any of the others. The tanks are lined with a heavy asbestos material to prevent groundings of any live parts in case the

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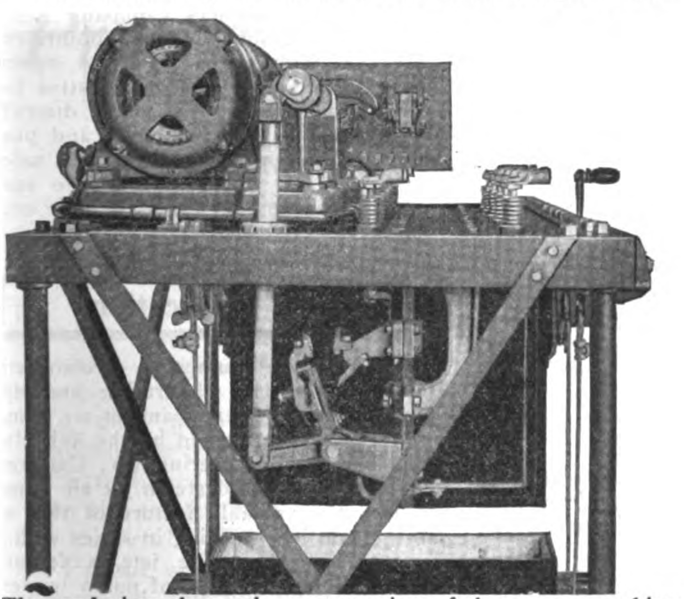
WITH THE EQUIPMENT MANUFACTURERS

tank is pushed out of place and also as an additional safeguard in case of sludging of the oil.

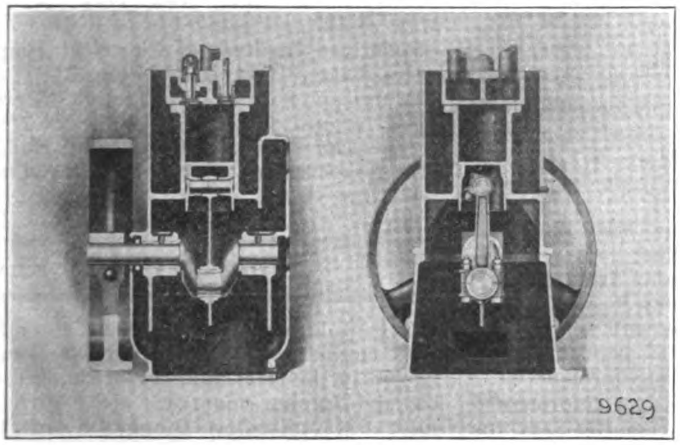
The contactor panel shown at the extreme right is controlled from a master switch or push buttons and handles the motor currents. Very little current is required as the motors used have high resistance motors. This particular reversing switch was made by the Cutler-Hammer Manufacturing Company of Milwaukee, for a 1,200 hp 220-volt mine hoist motor. It may be used for two motors on non-reversing service, or where only one non-reversing motor is required the switch is made with only one 3-pole unit and one motor.



This end view shows the construction of the contact making members; the arc being broken horizontally rather than vertically.

THE LATEST IN SMALL AIR COMPRESSORS.

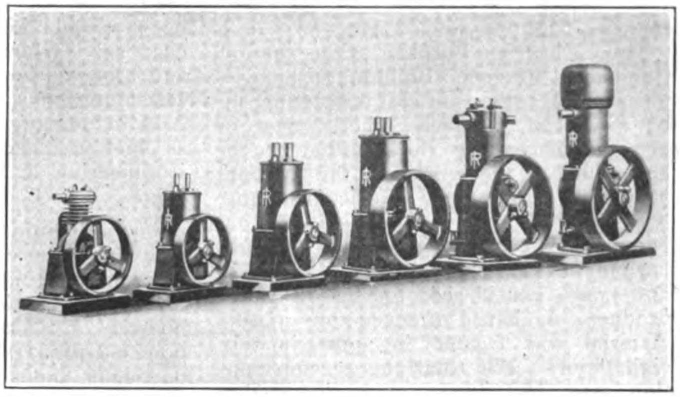
When, in the emergency at the outbreak of the war, there was a sudden call for a large number of small air compressors for service where reliability was imperative, the Ingersoll-Rand Company's offer, to produce for immediate use the Imperial Fourteen Compressors which it had just completed testing out and had adopted as the new standard small compressor type, was accepted. The field performance of these built-on-hurry-order machines was watched with critical eye, but after a year's service their record was clear. They had proven themselves efficient, reliable, and inexpensive to operator.



Sectional view of compressors.

These little machines as shown in the illustrations have been placed on the general market. There are four sizes and the capacity range runs from 3 to 45 cubic feet per minute at pressures to 100 pounds per square inch. The small compressors can however be used for pressure requirements up to 200 pounds per square inch, the horsepower needed being, of course, slightly increased. They are single acting machines of the vertical type built for belt drive. Where driven from line shaft, tight and loose pulleys are supplied; where the use of independant motor is planned they are ordinarily furnished as a unit complete with motor, endless belt and short drive attachment. In the latter case a hardwood base plate is included with the standard equipments.

The machines are so well balanced as to operate satisfactorily if bolted to any solid flooring, but where permanency of installation is desired the building of a concrete foundation is advocated. The smallest size is built with ribbed cylinder for air cooling where the service is intermittent and with water cooled cylinder of the reservoir type for continuous operation. Larger machines are water cooled only, employing the reservoir jacket system except that, in the case of the largest size, a closed jacket for connection to pressure system is optional. In this connection it is worth noting that the reservoir cylinder design affords unusually ample water capacity and that both cylinder barrel and head are cooled. The manufacturer states that a single filling of the water space will suffice for a 10 hour day's run.



Typical small Ingersoll-Rand compressors.

In general design the Imperial Fourteen Compressors remind one strongly of an automobile engine. There is the same drop forged crank shaft and connecting rod, the die cast renewable bearings, the automatic splash lubrication system and general ruggedness and simplicity which have come to be recognized as guarantees of satisfactory service under all sorts of operating conditions.

It is pointed out, however that these little units were designed to meet exacting efficiency test and that, while simplicity was sought, efficiency was the outstanding requirement.

The Industrial Steel Castings Company has been incorporated with a capital of $100,000, and has taken over the plant of the former Taylor Coupler & Castings Co., at Toledo, O. The new concern expects to start the manufacture of steel castings about June 1, and will have an estimated capacity of about 2,500 tons per year.

Trade Notes

The American Steam Conveyor Corporation, Chicago, announces the appointment of Charles H. Florandin, formerly of the National Electric & Welding Co., New York, as general manager of their Eastern territory, with headquarters at their New York office, 110 West Fortieth street. Mr. Florandin, who assumes charge of his new duties May 1, was born in France and received his technical education at the famous Lycee de Marseilles. He is an engineer by profession and upon coming to the United States did important work with the Brooklyn City Railway Company in the early days when the road was being electrified. After five years service with this company, he joined the C. & C. Electric Co., New York, where he held a responsible position with them for many years. After a brief connection with the Western Electric Company, he returned to the C. & C. Electric Co., and later organized the National Electric & Welding Co. During the war Mr. Florandin was a member of the welding committee of the Emergency Fleet Corporation and here did valuable work for our country.

The Electric Furnace Construction Company, Finance Building, Philadelphia, reports the successful starting up of a special Greaves-Etchells type of electric furnace for the manufacture of corundum at the works of the William McGregor Company, Airdrie, England. The material used is the waste dust accumulated from the crushing of natural corundum. This was practically useless and was considered to be a waste product. A charge of seven tons of this material was treated in approximately eight hours. The total energy consumption was 3,850 units, and the usable corundum ingots weighed nearly four tons. Results of the tests made gave great satisfaction and promise a new field for the electric furnace. We understand that fairly constant load was obtained throughout the whole of the operation.

Briggs & Turivas, Inc., Iron and Steel, Westminster Building, Chicago, Ill., have opened up a New York office at 1805 Equitable Trust Building, to be under the direction of Carl R. Briggs, president.

D. Gleisen, chairman board of managers, industrial division, General Motors Corporation, and manager industrial bearings division, Hyatt Roller Bearing Company, announces the appointment of P. C. Gunion as advertising manager industrial division, General Motors Corporation.

The Electric Furnace Construction Company, Finance Building, Philadelphia, reports the successful starting up of a Greaves-Etchells electric furnace at the plant of the Davidson Tool Manufacturing Corporation, Brooklyn. This furnace is used in conjunction with Mr. Davidson's special process for the manufacture of high speed steel castings. Remarkable results have been achieved in the manufacture of high speed steel cutters, drills, boring tools, etc. They also report the starting up of a 6-ton furnace at the Navy Department, Mare Island. In England a Greaves-Etchells furnace have been started up for the Tyne Electric Steel Foundries, Ltd., for the manufacture of steel castings.

A. S. Knowles has severed his association with Freyn, Brassert & Co., Engineers, Chicago, as consulting engineer in by-product coke oven matters.

The Bailey Meter Company will move its main office and works from Boston to Cleveland, O., effective May 1. The Boston office, with H. D. Fisher as manager, is retained to handle sales and engineering service work in the New England district. For the present New York and Philadelphia districts will be covered from Boston and all other districts will be covered from Cleveland.

C. C. Wallace, formerly manager of loading of munitions section of the Stenotype Company, Indianapolis, Ind., is now director of development and service of the Powdered Coal Engineering & Equipment Co., of Chicago.

Capt. A. U. Wetherbee, who recently received his discharge from the chemical warfare branch of the service, and who was formerly chief engineer and assistant works manager of the Niagara Alkali Company, has accepted a position as chief engineer with the Powdered Coal Engineering & Equipment Co., of Chicago.

An authentic treatise on "malleable iron" has been written and published and is issued gratuitously by the American Malleable Castings Association, headquarters, Cleveland, O. Although phenomenal progress has been made in this particular industry during the last few years, little or no progress has been made in keeping the public informed regarding such activities. The latest booklet, although but a forerunner for a very comprehensive volume to be issued later by the association, is filled with most valuable data. It is divided into three parts:

Part I.
What is Malleable Iron?
Part II.
The American Malleable Castings Association.
Part III.
The Uses of the Malleable Iron Casting.
Can Heavy Sections of Malleable Iron Be Completely Annealed?
The Skin of a Malleable Iron Casting.
Malleable Iron Castings Resist Rust.

A copy of this book will be sent to anyone mentioning this paper if they address the association at Cleveland, O.

The Bonnot Company of Canton, O., report a good volume of business for their Holbeck pulverized coal system. They have just announced an increase in capital stock from $500,000 to $1,000,000. The additional stock is 7 per cent preferred, and is made necessary by the increased volume of their business. They have been operating since 1891, manufacturing a line of clay working machinery and equipment for Portland cement plants, in addition to their powdered coal system. The officers of the company are L. C. Bonnot, president; Henry W. Harter, vice president; A. A. Oldham, secretary and treasurer. A. A. Holbeck is manager of the pulverized coal department.

The Celite Products Company takes pleasure in announcing the appointment of Frank Bethune, 808 Perdito street, New Orleans, as their representative for the Louisiana and Mississippi district. Mr. Bethune is widely known and possesses engineering knowledge and sales experience that will enable him to successfully handle the wants of their customers in this district.

Trade Publications

Steam Jet Air Pumps — Preliminary Bulletin No. 113, illustrating and describing the Wheeler steam jet air pump is now being distributed by the Wheeler Condenser & Engineering Co., Carteret, N. J. This patented steam jet air pump includes the valuable feature of two or more steam jets working in series with a condenser between the jets, a feature which enables this type of pump to perform a given duty more efficiently than any steam jet pump not so equipped. The bulletin explains the operating principles, gives reasons for high efficiency, minutely describes the inter-condenser, cites an interesting case of unprejudiced testimony and shows an operating test curve. It includes a cross sectional drawing and shows how to connect double machines or triple machines to surface condensers. The pump is applicable to jet condensers, as well as to surface condensers.

Society Meetings

American Iron and Steel Institute, Pennsylvania Hotel, New York, N. Y. May 23-24.

American Institute of Electrical Engineers, Lake Placid, N. Y. June 23-27.

American Society for Testing Materials, Atlantic City, N. J. June 24-27.

American Railway Bridge and Building Association, Cleveland, O. Oct. 21-23.

Obituary

J. E. Johnson, Jr., prominent consulting engineer and metallurgist, well known in the steel industry of this country and foreign countries, died April 4, 1919. Mr. Bradley Stoughton in an appreciation of him said: "His discoveries and inventions in the metallurgy of iron have established his reputation in every civilized country where iron and steel are made."

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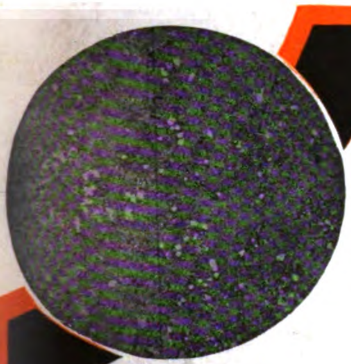
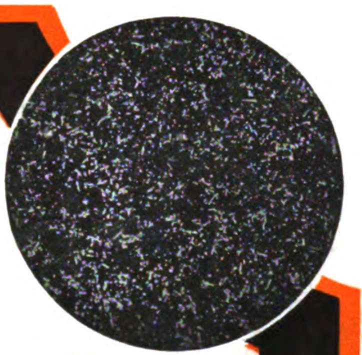
The Blast Furnace and Steel Plant

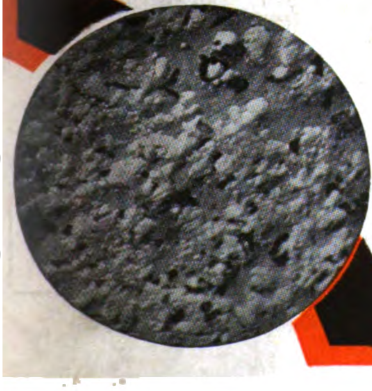
Pittsburgh, May, 1919.



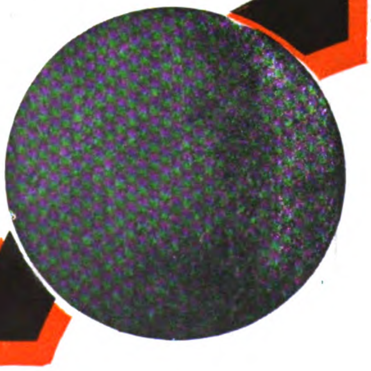
Tin, Lead and Antimony



Genuine Babbitt



Tin, Copper and Spelter



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